# UNDERSTANDING SCIENCE

# UNDERSTANDING

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ISSUED

# SCIENCE

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*Printed and published January, 1940.*
*Reprinted May, 1941.*

# TO THE STUDENTS WHO USE THIS BOOK

You are beginning a new year's work in science. As you use this book you should gain a much better understanding of some of the facts and principles that we call science. The facts help explain many of the things that you see every day, and many of the happenings that go on all about you. We are interested in trying to answer some of the many questions that you frequently ask. These are often the "what" and "why" questions, and sometimes the "how" questions.

Did you ever ask, "What are rocks?", or "Why do we breathe?", or "What holds us to the earth?" Have you asked someone such questions as: "How can heat get from one place to another?", or "How can heat make an engine go?", or possibly, "How do lamps make light?"

Now turn through the pages of this book. You will find here and there at the beginning of each unit division a list of problems expressed as questions like those above. Select any one question. Can you answer it? Now if you will turn in the book to the same numbered problem, you will find help in answering the question and in explaining how the answer is obtained.

We hope that you will have many questions of your own as you work with this book and that you will be able to get help in answering many of them.

Science means the attempt to explain the nature of the things in the universe in which we live. Science also attempts to explain how the things in our world behave and to further explain why they behave as they do. Science often means the ways that we use to find out and prove the explanations of the world in which we live. These are called scientific methods.

From your study of science you will learn much that will give you a better understanding of this modern world. Our world now is made up of many applications of science and even to live comfortably in it every person must have some understanding of science. We expect one result of your work with the material in this book will be that you can better adjust your living to your own daily surroundings.

The work to be done is divided into eleven large divisions called units. Each unit is developed around the same general work pattern. You will find for each unit a brief introduction, *What This Unit Is About.* Then follows the list of numbered *Unit Problems.* The text to be read follows the statement of the unit problems. In the text you will find suggestions of things to do introduced at places where they seem to help in the learning. These are printed in *italics like this type.* In addition there are frequent questions and problems. You will find it to your advantage to try to answer these.

Again turn the pages of this book. You will see many unusual and interesting pictures and diagrams. These help very much in making the book an attractive tool to use. There is no doubt you will enjoy just looking at many of the pictures. If you will examine these more carefully, you will find that each has a story to tell. Study the pictures and diagrams as you read the text. Very often it will pay you to look at an illustration, read what is printed with it, and then examine the picture or diagram again. The pictures are intended to help in explaining the words of the text and the words are intended to help in explaining some of the pictures and diagrams. Learn to use both in building up a better understanding of the ideas presented.

At the end of each unit you will find directions for *Things* *to Do* in addition to those that are suggested in the text. You should try some of these. These directions include things to be done by the whole class or by committees. Following the things to do is a unit summary, *Some Things to Remember*. These numbered statements will assist you in reviewing what you have learned in a unit. Always try to think of other ways to apply the ideas contained in each of these summary statements. Finally, you will find a list of *Books to Read*. One book cannot contain all that is known about many science topics. Use these suggested readings to add to what you have learned from your textbook.

There are always interesting pieces of work for alert and energetic boys and girls. If you finish the work expected of members of your class, try some of the other activities in the list of *Things to Do*. Read one or more of the books in the reading list. Perhaps you can think of other problems of your own, or of an interesting report or demonstration that you can carry out. Ask the teacher to approve your project and then see if you can make a worth-while contribution to the work of the class.

Ralph K. Watkins
Winifred Perry

# ACKNOWLEDGMENTS

The authors wish to acknowledge their indebtedness for the following illustrations: *All the Children:* page 361; The American Jersey Cattle Club: page 376; The Boston Dispensary: page 417; Bureau of Mines: page 238; J. I. Case Company: pages 42, 241; Cornell University Agricultural Experiment Station: page 51; Frank Wiggins Trade School, Los Angeles: pages 33, 34, 35; General Electric Company: pages 280, 342, 395; George School: page 399; Dr. R. E. Gibson and *The Scientific Monthly:* page 234; Ground Gripper and Cantilever Shoes: page 402; Johns-Manville: page 306; Lick Observatory: pages 202, 203, 205; Los Angeles Department of Water Supply: page 381; National Association of Audubon Societies: pages 144, 149, 384; National Geographic Society—United States Army Air Corps Stratosphere Flight: pages 44, 45 (copyrighted); New York Central System: page 288; The News: page 20; Northampton School for Girls: page 307; *Popular Science* and Paramount Pictures: page 11; Pyrene Manufacturing Company: page 313; San Diego California Club: page 200; Taylor Instrument Companies: pages 83, 92; Timken Roller Bearing Company: page 268; Union Pacific Railroad: page 289; United Motors Service: page 268; United States Bureau of Biological Survey: page 386; United States Department of Agriculture: page 366; United States National Museum: page 303; University of Missouri College of Agriculture: page 21; Westinghouse Electric and Manufacturing Company: page 336; The Wild Flower Preservation Society, Inc.: page 389; Wright Aeronautical Corporation: page 291; Yerkes Observatory: pages 190, 191.

Other illustrations have been obtained from: American Museum of Natural History: pages 26, 69, 122, 143, 171, 255, 299, 367 (copyrighted); D. Anderson: page 375; L. W. Brownell: pages 86, 87, 88, 136, 154, 388; Lynwood M. Chace: page 153; Culver Service: page 187; Field Museum of Natural History: pages 132, 182 (copyrighted paintings by Charles R. Knight); Ewing Galloway: pages 18, 19, 39, 49, 50, 68, 73, 78, 79, 111, 115, 129, 221, 223, 226, 282, 285, 292, 305; Philip Gendreau: pages 30, 65, 67, 120, 284; Lionel Green: pages 124, 222, 293, 305; International News Photos: page 286; I. Janowitz: page 217; Kaufmann-Fabry Company: page 238; Keystone View Company: page 31; Luckhaus Studio: page 193; J. Horace McFarland Company: pages 61, 172, 173, 374; Meisel from Monkemeyer Press Photo Service: page 89; New York Zoological Society: pages 10, 163, 164; H. Armstrong Roberts: pages 5, 12, 58, 63, 222, 284, 305, 380; James Sawders: pages 102, 125, 133; Science Service: pages 1, 8, 55, 230, 232, 251, 266, 308, 309, 311, 320, 324, 328, 329, 347; Hugh Spencer: pages 134, 138, 139, 141, 156, 160, 167, 179, 236, 363; Strohmeyer and Carpenter: pages 368, 369, 377; Triangle Photo Service: pages 43, 59, 119; Underwood and Underwood: pages 6, 48, 50, 100, 270, 339, 359, 373; Wide World Photos: pages 361, 380.

The drawings for this book were made by Adrian J. Iorio and John Charles Smith.

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# UNDERSTANDING SCIENCE

# UNIT ONE

## UNIT ONE

# Solving Our Own Science Problems

### WHAT THIS UNIT IS ABOUT

Science deals with the nature of things in the universe in which we live, and with the ways in which these things behave. If we are scientific, we do not accept a thing as true unless it can be proved. We try to gather reliable evidence to show the truth.

Susan says that it is going to rain when the science club has its picnic. "It always rains on the first picnic in the fall." She doesn't want the picnic spoiled, but she would like to have it rain just a little to prove her contention. As further proof, she adds that it is near the fall equinox, and her grandmother says that it always rains at the equinox.

Rain is one of those things we call natural phenomena. It is a part of our surroundings, or environment. Rain, and its causes, belong to that field of human knowledge which we call natural science. The statement that it always rains at the time of the first school picnic in the fall is a doubtful statement. It is based on insufficient evidence. Susan has no records to show how many times it has rained on a school picnic. She just thinks she remembers. She has no records which can be counted and reduced to figures. She cannot say, "Here is a record of ten school picnics held on the 21st of September, one every year for the ten years, and out of the ten it has rained nine times."

Grandmother's evidence is little better, although many other people believe the same thing. Her belief is incorrect because she has connected two happenings that by chance have occurred at the same time. We try to explain fall rains, which we do not otherwise understand, by something that happens at the same time, in this case the change of the seasons.

We could go to the weather records to get evidence in a case like this. The weather man, who is a trained scientist, can tell whether or not it is likely to rain on the day of the picnic. He can do this because he can collect for that day carefully measured observations about the condition and movements of the air from other trained observers located all over the country.

In scientific work we usually expect that the proof will consist of evidence we can observe with the senses of seeing, hearing, feeling, tasting, or smelling. Very often we require that the evidence be of a kind that can be measured or counted. If we have what is called a *scientific attitude*, we delay arriving at a conclusion or forming a judgment until there is enough evidence to prove the point. A scientist tries to be impartial in considering his evidence. He does not assume that a thing is proved true or false. He waits until the evidence shows which is the correct answer to his problem.

In this unit we shall try to learn the difference between science and false beliefs. The latter may be either *fallacies* (false ideas) or *superstitions* (a belief built on false ideas). We shall try to find out how we can make controlled observations of science phenomena or happenings. We shall try to find out when to believe, and when not to believe, statements that are supposed to belong in the field of natural science.

# Solving Our Own Science Problems

## UNIT PROBLEMS

1. What is the difference between fallacy or superstition and science?
2. When are we to believe a "tall" story?
3. What are we to believe about new discoveries in science?
4. How are things proved in science?
5. Can we solve science problems for ourselves?
6. How do we find answers to our own science problems?
7. How can we experiment at home?
8. Who are scientists?

## WHAT IS A SCIENTIST?

### 1. What is the difference between fallacy or superstition and science?

Sometimes when people see two things happen at the same time on several occasions, they say the one is the cause of the other. Suppose that in walking along the street you see a peculiar brown stone and put it in your pocket. Later in the same walk a friend happens to see you and says, "Come to the circus with me." Perhaps the next time you are about to go for a walk you find the brown stone and remember that you picked it up the day you went to the circus. Suppose that on this second walk you meet a friend who says, "I'm going to the country for two weeks. Do you want to use my bicycle while I'm gone?" Now you think to yourself, "I

SUPERSTITION STILL EXISTS IN SOME PARTS OF OUR PRESENT WORLD.

always have good luck when I carry that funny-looking brown stone. It's a lucky charm. I'll carry it wherever I go." You have built up a superstition. Because nice things happened to you when you carried a peculiar little stone, you have come to believe that these things happen because of the stone.

People have often used a superstition to explain something which they could not understand. Thunder and lightning make a vivid impression on all people. Many folk are afraid during a thunderstorm. Years ago the Greeks tried to explain the cause of thunder and lightning. As you probably have read, Zeus was the chief of the Greek gods. The Greeks thought of him as a superman with magical powers, but with the feelings of an ordinary man. When Zeus became angry, he hurled his thunderbolts at those who had displeased him. It should have been easy to prove that lightning occurred when there was no apparent reason for anger on the part of the gods, and equally easy to prove that lightning often did not occur when there might have been some reason for displeasure at the behavior of human beings.

Many people still believe in a variety of superstitions. These are usually associated with fears of various kinds. To break a mirror means seven years' bad luck for the unfortunate breaker. Carrying a rabbit's foot brings good luck. It is bad luck to pass under a ladder. Carrying a horse chestnut in the pocket wards off rheumatism. A black cat crossing the road ahead is a sure sign of some calamity. Stepping on a crack in the sidewalk will break your mother's back. When the dog grows a thick coat of fur in the fall, it is a sign of a severe winter to come. Short sections of color in the covering of striped woolly caterpillars are a sign of a short winter; long sections are a sign of a long winter. A new moon turned up so that it will hold water indicates dry weather; a moon turned down to spill the water indicates wet weather. Wars are sent as punishments for the wickedness of sinful people.

DO YOU BELIEVE THAT ANY LIFELESS OBJECT CAN BRING YOU LUCK?

*Make a list of ten superstitions which are believed by various people in your community, or which were at one time believed by some of the older people. Make a combined list of the superstitions gathered by the different members of the class. What is the accepted explanation for each of these now?*

Instead of accepting the superstitious explanation of a coincidence (two or more things that just happen to occur at the same time), the scientist tries to find what is the natural cause for things that happen in the world and to prove with evidence the relationship between the cause and the effect.

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DO YOU THINK SCIENCE OR SUPERSTITION TAUGHT PEOPLE HOW TO PREVENT MOTH DAMAGE TO WOOLEN CLOTHES AND FURS?

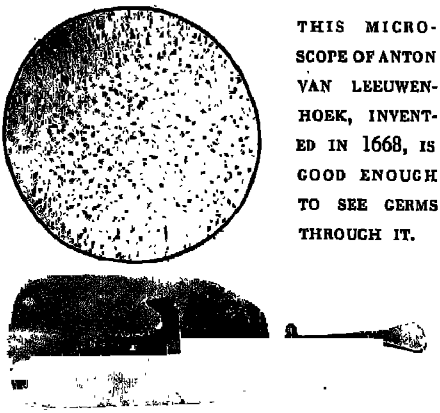
For many years people believed that living things could grow from inert or dead material. The name given to this was *spontaneous generation.* There are even recipes in old books on farming telling how to get living things by some peculiar combination of nonliving materials. One fact that led to the belief in spontaneous generation was that living creatures often came from meats.

An Italian scientist named Redi doubted the idea of spontaneous generation. He tried to find a natural explanation or cause for the presence of living creatures in meat kept for some time. To do this he placed samples of meat in bottles which were screened over the top with pieces of cloth. He found that flies came around the bottles and laid eggs on the cloth. Maggots developed from these fly-eggs, but none were in the meat. Redi concluded that the explanation for the growth of living things in the meat was that these were maggots which came from fly-eggs laid in it. He repeated his experiment many times. Each time that his meat was carefully screened, he had no living creatures in it.

This work of Redi stood until the invention of the microscope in 1668 by Anton van Leeuwenhoek of Holland. With his microscope Leeuwenhoek discovered minute living things that could not be seen with the naked eye. This opened again the whole question of spontaneous generation. More than a hundred years later the French scientist, Pasteur, discovered that, when he subjected substances to heat and kept them in heat-treated vessels covered from the air, he had none of the living creatures that can be seen under the microscope.

Now we believe that all living things come from other living organisms of their own kind. Scientists have found natural and logical explanations for those happenings that seemed to produce life spontaneously. Until something else happens which makes us question the experiments of some of these scientists, we shall continue to believe that each living thing has come from some other living thing like it. We class as superstitions or as fallacies the notion that worms come from sea mud or that horsehairs in watering troughs turn into snakes.

Many modern advertisers would like to establish the kind of belief in the value of a trademark that the ancients had for charms and luck pieces. You are to believe that the kind of article carrying a particular trademark is always good. If you can find that the samples bearing this trademark are good, then perhaps you can be made to believe that all articles marked in this particular way are always good. The next step is to believe that no other articles of this kind can be as good as those bearing this one peculiar mark. This is very close to the kind of belief that we



THIS MICROSCOPE OF ANTON VAN LEEUWENHOEK, INVENTED IN 1668, IS GOOD ENOUGH TO SEE GERMS THROUGH IT.

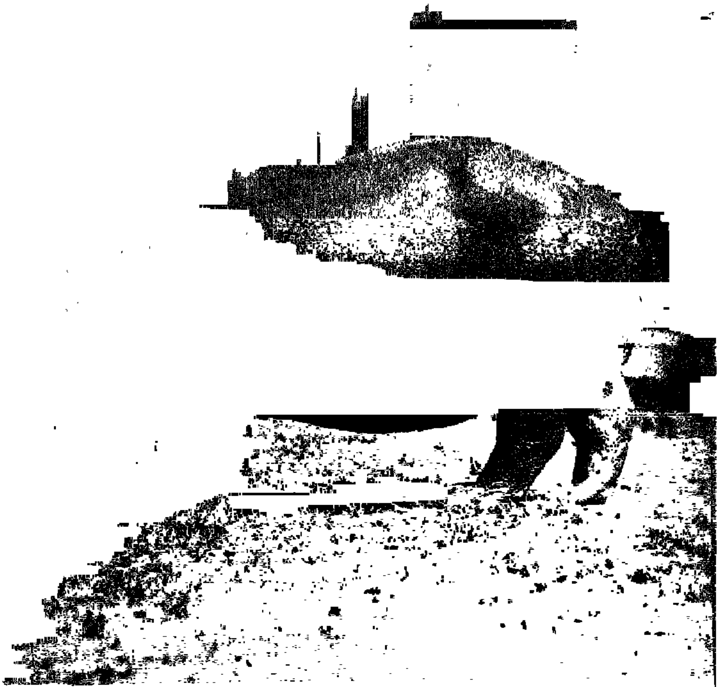
laugh at as an old-fashioned superstition. It is superstition in a new form. Of course, a trademark is often a symbol of good workmanship. Such a trademark does not, however, indicate that similar articles made by other honest workmen may not be just as good, or in some cases better. The scientific purchaser will try to find out which articles are better.

## 2. When are we to believe a "tall" story?

Sometimes people in a community start a story that seems greatly exaggerated, but which many continue to believe. Often there are eyewitnesses who swear to its truth. Stories of this kind are frequently reported in the newspapers. The name "tall" stories is sometimes given to them. When are we to believe a "tall" story? How are we to know what to believe? Sea serpent tales are typical of such stories.

A proposed scientific treatment for a sea serpent tale was reported in the issue of *Time* for June 20, 1938. In part it runs as follows:

> Like a steel-blue knife blade pressed flat into the heathery Scottish highlands lies 22½-mile Loch Ness. Natives of the district have for centuries been seeing kelpies, bogies, will-o'-the-wisps. Relatively young, relatively real to the outside world is "Nessie," the lake's mysterious monster, "seen" every season since 1933.
>
> Last week, Captain Donald John Munro . . . opened the 1938 season. . . . He proposes to build three lookout towers, each equipped with a telephoto camera, range finder, stop watch, powerful binoculars, sound apparatus like that used for detecting the presence of submarines . . . (He) will determine Nessie's size, her speed of travel, and whether she is, as various eyewitnesses and scientists have declared: (1) an elephant seal which swam in from the North Sea via the Caledonian Canal; (2) a hippopotamus; (3) a 50-ft. prehistoric reptile with a whiskery pinhead and eight scaly humps; (4) a giant squid; (5) "an abomination with a three-arched neck"; (6) a cold-blooded crocodile; (7) a cool fabrication.



COULD THIS BE A SEA SERPENT? GIVE REASONS FOR YOUR ANSWER.

> Captain Munro is a 69-year-old sea dog who retired from the Royal Navy after 30 years' service . . . His naval training prepared him specifically for Nessie, for during the War he devised and carried out all British harbor defense against hostile submarines.

Captain Munro's proposed photographic and other apparatus *should be able to produce recorded evidence* which will determine Nessie's nature if she exists at all. A series of photographs would make better evidence than hurried glimpses by frightened people.

Ordinarily we should withhold our judgment of a tall story until there is more evidence than the tales of some untrained and inexperienced persons. Very often we can check in terms of known facts so that we can get some idea of whether or not the story is probable. For example, the proposal that Nessie is a hippopotamus seems ridiculous when compared with what is known about hippopotami. Where do hippopotami live? In what kind of a climate? If one had escaped from a zoo, could it survive in Scotland?

*Try to find what seems to be another "tall story" in a recent newspaper. Bring your story to class. What is your explanation of the story?*

### 3. What are we to believe about new discoveries in science?

Often the reports of new findings made by scientists seem as improbable as the tall stories which find their way into the newspaper columns. For example, these things have been recently announced in the science magazines: the making of wool from fish products and cellulose after the fashion of modern rayons; the making of wool from the casein of

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HAVE YOU SEEN REPORTS OF THIS WONDERFUL NEW "DISCOVERY" ANYWHERE EXCEPT IN NEWSPAPER OR MAGAZINE ADVERTISING?

statement. If such a find is reported in *Science News Letter* as being announced by a famous astronomer, we are inclined to believe it possible and look for announcements of further evidence. If this finding is reported from the Lick Observatory in a scientific paper, we feel more certain. If then it is commonly accepted by astronomers other than the one making the find, we believe it until further evidence is presented which may disprove it.

In cases where new scientific discoveries are announced we may well ask some questions. Who made the discovery? What training had this person in science? What is this institution?

Is it commonly recognized as having a good reputation? Who is responsible for the publication of the newspaper, magazine, or book in which the report is made? Is the organization publishing the report one of recognized honesty and scientific reputation? Is the announcement made for the purpose of getting the public to buy something?

We are inclined to doubt all claims to wonderful new scientific discoveries which appear in advertising in newspapers, magazines, or by radio. If such a discovery concerns us, all such claims should be checked by sources that are not interested in the report for profit. If the product is a medicine, check it with your family physician or your nearest public hospital.

If an announcement of a famous discovery is found in the magazine section of a Sunday newspaper, try to find it in some magazine published by a group of scientists, or ask a trained scientist if he thinks that the discovery is possible, or probable.

If a new scientific discovery is announced by a man known to be a scientist and is found in the ordinary news columns of a newspaper, or in a magazine devoted to science, accept it as a possibility, and look for later and added evidence which will surely be published within a reasonable time if the thing claimed is true.

*Find in a current newspaper or magazine a report of a new scientific discovery. Who has made the discovery? Is it likely that the report is true? Where did you find the story of the discovery? Is the story found in a piece of advertising? Is someone trying to sell the thing that has been found?*

### 4. How are things proved in science?

It will help us to find what we can believe or what we can safely use if we understand something of the ways in which scientists prove their findings. Frequently when we hear the expression, *scientific method*, we think of an experiment to demonstrate that a thing actually works as it is supposed to work. Instead of believing what someone tells us, or what we read in a book, we try out a process to see what happens.

A famous story about Galileo is often told to illustrate the method of experimentation, or trial. At the time of Galileo (1564–1642), nearly all science was taught from the books of Aristotle. To prove a point, a teacher of science simply stated that Aristotle said it, and quoted a passage from one of Aristotle's books. Among other things, Aristotle had said that objects of different size fall toward the earth at a rate in proportion to their weights.

For some reason Galileo doubted this statement. He took cannon balls of different sizes up to the top of the famous leaning tower of Pisa and at the same time dropped them from the top. He found that objects of different weights struck the ground at the same moment; the rate of fall was not in proportion to their weights. He repeated his experiments until he was convinced by his evidence. He then went to the University of Pisa and invited his fellow teachers to a demonstration. These men watched the cannon balls of different sizes dropped at the same time and saw them strike the earth at the same moment. They shook their heads and said, "But Aristotle says," and went away disbelieving what they had just seen. You can understand why Galileo is sometimes called the father of the experimental method of proof.

Suppose that a friend says, "My roller skates are ball-bearing and will roll much farther than yours." Instead of arguing the case, why not try the two kinds of skates and see what happens? Take one skate of each kind and start them from the top of an incline and see which rolls the farther.

Try this experiment several times before forming a conclusion that the ball bearing skates will roll the farther.

**One Trial Not Enough.** The scientist considers one trial of little value. The conclusion formed as a result of only one trial may be incorrect because of some error in observation or because of some interference which does not occur in other trials. An experiment is repeated until the observer is sure enough of the outcome to say that other trials in the future will come out the same way.

**The Need for Measurement.** In most work in science, it is necessary to use some unit of measure in order that more accurate records can be made of the observations. If experiments are to be repeated, it is necessary to use the same measures for each repetition and to make the records of the experiment in the same units of measure.

Ben says, "I can run faster than Martin." Martin denies this. How can we find out which is right? The answer is, of course, to have a race. But immediately the question arises, how far are the boys to run? As soon as this question comes up, we have need for a measure. We can say the boys are to run from the edge of the sidewalk to the big oak tree. This is not as convenient a unit of measure as, for instance, a hundred yards, but it is a measure and can be used in the proposed experiment. If Ben covers the distance between the walk and the tree more quickly than Martin, we shall agree with his original claim. Perhaps we shall say the race should be the best two out of three, a repeated experiment.

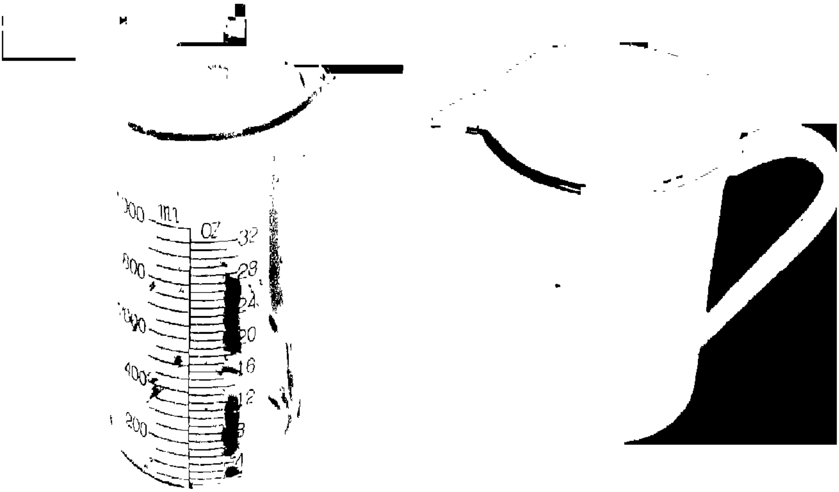
If some one wants to know how much faster Ben runs than Martin, or simply how fast Ben can run, we need another kind of measure. We need a unit to measure the time. For this purpose we use units called hours, minutes, and seconds. The instrument used is a clock or watch. With a watch we find that Ben covers the distance from the walk to the tree

ACCURATE MEASUREMENTS ARE NEEDED TO SOLVE SCIENCE PROBLEMS.

in two seconds less time than Martin. To compare this with other records we need a measure that is commonly used by many different people as, for example, the yard. If we know how many yards Ben and Martin run in so many seconds we can compare their running with thousands of boys whom we have never seen.

*Turn to your junior-high-school mathematics book and list the different kinds of measures that are described in it. Can you tell how each of these measures can be used in science work?*

The Need for Records of Measurements. Much work in science requires the keeping of measured records for purposes of making comparisons. For these records to be of any value they must be made in terms of uniform units of measurement. Every observation must be taken as nearly as possible under the same conditions. The instruments used must be the same, or must be carefully compared, to see that they produce the same units of measure. If you say to a friend, "I'll meet you at the front entrance to the school building at 8 o'clock," it is well to compare watches to be



MANY KINDS OF INSTRUMENTS ARE DEVISED FOR MEASURING.

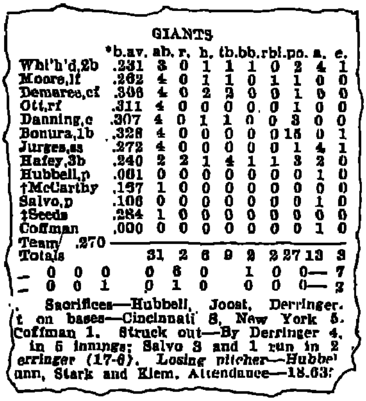
sure the two watches are near enough together to make it possible for both of you to keep the appointment on time.

Many problems dealing with the weather require careful records made under the same conditions, with similar instruments, and in the same units of measure. Grandfather says that the climate is changing. The winters are not nearly so cold as they once were. Summers are hotter and drier. What do the records of the nearest station of the weather bureau show? Weather bureaus may have records of temperatures taken in the same units with a Fahrenheit thermometer at the same hour of the day on the same day for the last forty or fifty years. An average of the readings for January 15 taken for five- or ten-year intervals should show whether or not the winters are getting any colder.

A popular baseball hero is a great hitter. People say that he is much better than any other player of the last ten years. But is he? Newspapers have records made in terms of the number of hits in a definite number of games for all of the players in the major leagues for many years. A batting average is a unit of measure. The newspaper records make accurate comparisons of players possible. The question of whether the baseball hero is the best hitter can be definitely answered.

How many cases of accurate records of observations can you find reported in this morning's newspaper? *Clip sample records for the school bulletin board.*

**Controlled Experiments.** Sometimes it is difficult to prove the solution to a problem because we cannot control all of the conditions for an experiment. This is true of feeding experiments with animals. When a scientist wishes to find the effect of some change in the diet of an animal, he feeds his new food combination to one or more animals of a given kind, perhaps white rats. He cannot be absolutely sure that changes in the conditions of the rats are due wholly to the changed feeding. To be sure he feeds other rats on a normal or standard diet while he is experimenting with the food of the first set. The rats fed the changed diet are called the *experimental* animals. The rats fed the normal food are called the *control* animals. In all other ways, except the difference in feeding, the two groups of animals are treated just alike. After some weeks, the scientist should be able to find whether or not the new feeding produces any changes in his animals. He can judge the effect by comparing the experimental animals with those of the control group.



GIANTS

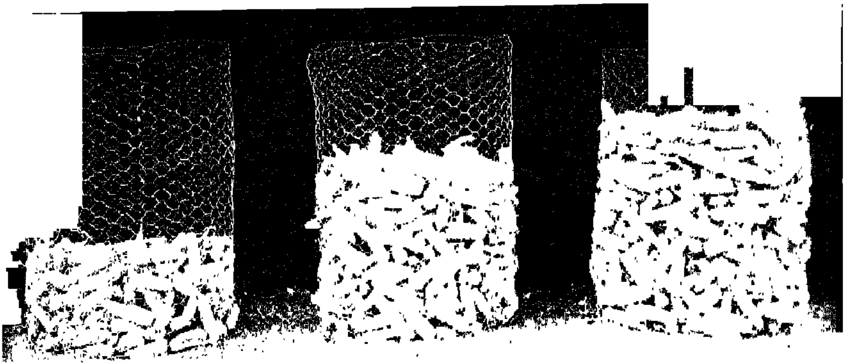
| | *b.av. | ab. | r. | b. | tb. | bb. | rbi. | po. | a. | e. |
|---|---|---|---|---|---|---|---|---|---|---|
| Whi'h'd,2b | .231 | 3 | 0 | 1 | 1 | 1 | 0 | 2 | 4 | 1 |
| Moore,lf | .262 | 4 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| Demaree,cf | .306 | 4 | 0 | 2 | 2 | 0 | 0 | 1 | 0 | 0 |
| Ott,rf | .311 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Danning,c | .307 | 4 | 0 | 1 | 1 | 0 | 0 | 3 | 0 | 0 |
| Bonura,1b | .328 | 4 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 1 |
| Jurges,ss | .272 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 1 |
| Hafey,3b | .240 | 2 | 2 | 1 | 4 | 1 | 1 | 3 | 2 | 0 |
| Hubbell,p | .061 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| †McCarthy | .157 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Salvo,p | .106 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| ‡Seeds | .284 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Coffman | .000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Team .270 | | | | | | | | | | |
| Totals | | 31 | 2 | 6 | 9 | 2 | 2 | 27 | 13 | 3 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| – | 0 | 0 | 0 | 0 | 6 | 0 | 1 | 0 | 0 | —7 |
| – | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | —2 |

Sacrifices—Hubbell, Joost, Derringer. t on bases—Cincinnati 8, New York 5. Coffman 1. Struck out—By Derringer 4. in 6 innings; Salvo 3 and 1 run in 2 erringer (17-6). Losing pitcher—Hubbe unn, Stark and Klem. Attendance—18.63

THE UNIT OF MEASURE IS THE FIGURE IN THE PERCENTAGE COLUMN. DO YOU KNOW HOW THIS IS FOUND? WHY MAKE A RECORD OF THE STANDING OF BASEBALL TEAMS?

This same process is used in trying to find out the effect of some forms of fertilizer upon growing plants of some



SCIENTISTS HAVE RECOGNIZED THE VALUE OF A "CONTROL" IN AN EXPERIMENT. THE CRIB OF CORN ON THE LEFT IS THE CONTROL. THE CORN WAS GROWN ON PLOTS OF SOIL HAVING DIFFERENT TREATMENT.

one kind. The experimental plants are treated with the new fertilizer. Alongside these plants are others not treated with this chemical but otherwise living under the same conditions. The second lot of plants form the control.

In some simpler experiments a control is useful. Suppose a saleswoman says a piece of cloth does not fade in laundering. To prove this you ask for a sample of the cloth. You try laundering the sample to see the effect. By the time the whole sample is washed you cannot be sure of just how it looked before. It is much better to cut your sample in half and wash only one of the pieces. Use the other part of the sample as a control for your experiment. Judge the effect of laundering one piece by comparing it with an untreated piece cut from the same sample. *Try this with a sample of cloth.*

### 5. Can we solve science problems for ourselves?

Many kinds of science problems must be handled by people with years of scientific training. We cannot expect to get solutions to problems of this kind for ourselves. This is true of most of our health problems. Instead of diagnosing our own ills and treating ourselves according to our own notions, or with some nostrum or patent medicine bought at the nearest drugstore, we consult a recognized physician or a surgeon, or go instead to the clinic of a neighboring hospital.

There are, however, a great many problems that can be solved at home. For example, a salesman says that the colors of a particular piece of cloth are sunfast. We can easily check this claim. *Get a sample of the material. Cut the sample in half. Keep one piece wrapped in brown paper in the shade. This is your control. Place the other piece in the sun every day for a week. At the end of the week compare the two pieces.*

What could you do with such a problem as this? Some one tells a "tall" story in which he claims that a dog can follow signals that make it necessary for him to distinguish between red and blue. Do you believe this? Can dogs tell colors? How would you set about trying to discover whether or not the family dog can distinguish between colors?

Two boys get into an argument about two kinds of bicycle tires. One boy claims that a tire that costs fifty cents less than another wears much better than the more expensive tire. The second boy claims that the expensive tire will wear longer. Do you think you could outline a method of settling this argument by a scientifically controlled experiment?

A girl says that a piece of ribbon is silk. Another claims that the ribbon is rayon. Is there any way to find out of which material the ribbon is made?

An advertisement in the local newspaper claims that there is a new chemical that when sprinkled on a lawn will kill dandelions without injuring the grass. Suggest some way to test this weed killer without danger of destroying the whole lawn if it turns out to be injurious to grass.

We can use scientific methods to solve our own problems if these involve experiments that we are able to carry out under home conditions without elaborate apparatus of a special kind, and if we understand the principles that are necessary for the experiment. Many problems that require accurate and careful observations, and records of these observations to make comparisons, will be possible for you. This latter kind of problem solving can be carried out if the problem does not require especially complicated and expensive measuring tools.

### 6. How do we find answers to our own science problems?

Our science problems often require a satisfactory answer to a difficult question. The solution to the problem may be known if we but know where to turn to find the answer. Such questions can be answered frequently by people with training of a certain kind whom we call specialists. For health problems these specialists are physicians, surgeons, and those doctors who treat special cases, such as those concerned with eyes, ears, or teeth. For problems dealing with road-building the specialist is a civil engineer. An architect is a person with special training in planning houses or buildings.

Many of our science questions can be answered by finding the proper reference in a book. Standard encyclopedias will answer many science questions. *Find the names of the planets in our solar system from the school encyclopedia.*

School textbooks in science contain answers to many questions. Facts about the nature of substances are found in books on *chemistry;* those about machines, engines, light, heat, and electricity in books on *physics;* those concerning rocks, minerals, and the structure of the earth in books of *geology;* those about living things and their life processes in books on *biology;* those about plants in *botany* books; those about animals in *zoology* books. *With the help of your teacher get a collection of school textbooks in these sciences. Examine each one enough to learn the nature of the material usually pre-*

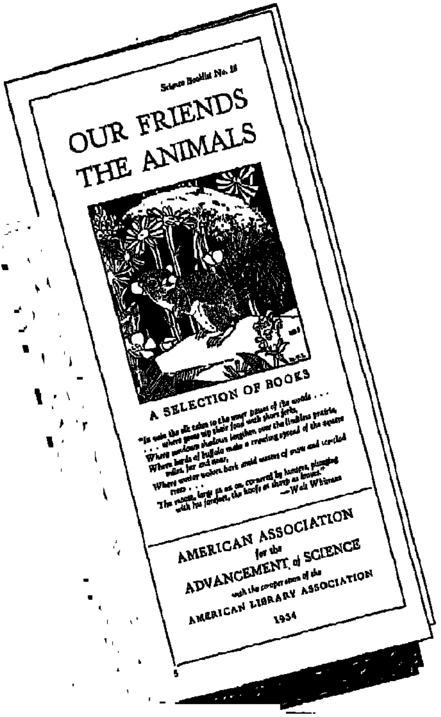
*sented in such a book. Report what you have learned to the class. You may wish to keep these books for reference.*

There are many popular books written about scientific discoveries, either for young people, or for people without specialized training in science. Usually these books are more readily understood than the textbooks. Your high-school library should have a number of these books. *Ask your teacher to post a list on the classroom bulletin board.*

**Reading Lists.** If more science books are needed for your school library, some carefully selected book lists will help with the choice. The American Library Association publishes a science book list. The headquarters of the Association are in Chicago. Sections of the reading lists prepared by the National Council of the Teachers of English for junior-high-school pupils deal with books on aviation, nature, and science and invention. The title of one of these lists is *Leisure Reading*. It can be purchased from the National Council of the Teachers of English, 211 West 68th Street, Chicago.

The American Association for the Advancement of Science publishes a series of book lists on different science subjects. There are twenty-seven of these. They deal with such subjects as wind and weather; fishes, frogs, and reptiles; birds; animal life; plants; the earth and its wonders; wild flowers; chemistry; and wonders of the sky.

LISTS OF RELIABLE AND WORTH-WHILE BOOKS ARE AVAILABLE FOR INTERESTED SCIENCE READERS.



Science Booklist No. 18

OUR FRIENDS
THE ANIMALS

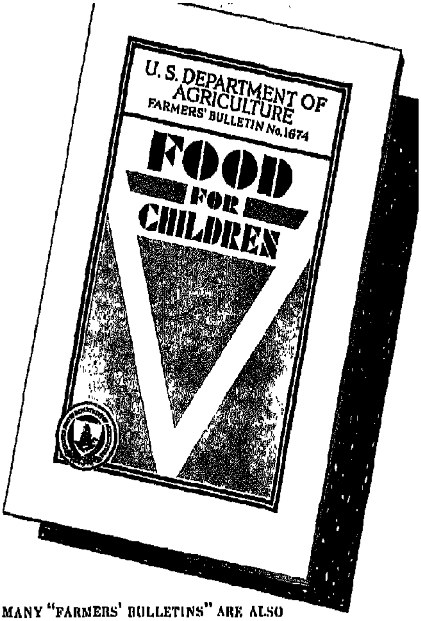
A SELECTION OF BOOKS

—Walt Whitman

AMERICAN ASSOCIATION
for the
ADVANCEMENT of SCIENCE
with the cooperation of the
AMERICAN LIBRARY ASSOCIATION
1934

These lists can be secured free of charge for school use by writing to the American Association for the Advancement of Science, Smithsonian Institution Building, Washington, D. C. By paying a small fee the whole set may be secured for home use.

If you live near a public library, you will find many of the books in these lists. The librarian at the loan desk will be glad to help you select the one which will best answer your questions.

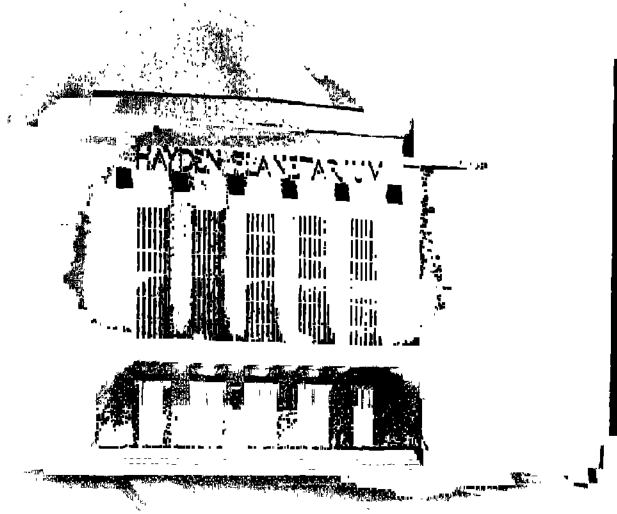


MANY "FARMERS' BULLETINS" ARE ALSO USEFUL FOR CITY DWELLERS.

There are a few interesting and reliable science magazines that can be easily read by people with little training in science. Some of these are: The *National Geographic Magazine*, *The Nature Magazine*, *The Science News Letter* (weekly), and *Hygeia.*

Several agencies of the Government publish bulletins for the information of the public. The most extensive list for general use is that of *Farmers' Bulletins* published by the Department of Agriculture at Washington. Many of these bulletins are just as useful to the city dweller as they are to the farmer. Some deal with selection of foods, growing backyard gardens, lawns, garden flowers, insect pests of the household, pets, household heating, paints, and plumbing problems. A complete list of the bulletins can be secured from the Department of Agriculture. Some of these are free and others can be bought at a small price.

*Write to the Department of Agriculture in Washington,*



THE PLANETARIUM IS A NEW TYPE OF MUSEUM FOR THOSE INTERESTED IN THE STARS. HAYDEN PLANETARIUM IS LOCATED IN NEW YORK CITY. ANOTHER EXCELLENT MUSEUM OF THIS TYPE IS FOUND IN CHICAGO, ILLINOIS. THERE ARE ALSO PLANETARIUMS IN SOME EUROPEAN CITIES.

*D. C., for a list of Farmers' Bulletins. Make a list of useful bulletins. Buy these for use in your class. Bulletins that are to be bought from any agency of the Government are purchased from the Superintendent of Documents.*

Museums, Gardens, and Zoos. If you are curious about plants, or animals, or scientific inventions, there are many fine museums, zoological gardens and botanical gardens that you can visit. Famous museums are the New National Museum at Washington, D. C.; the Field Museum in Chicago; and the American Museum of Natural History in New York

City. Famous botanical gardens are: The Missouri Botanical Garden in St. Louis, the Brooklyn Botanical Garden, The New York Botanical Garden, and the Arnold Arboretum of Harvard University at Cambridge, Mass. Famous zoos are the Bronx Zoo (New York Zoological Garden) in New York, the St. Louis Zoo, the Washington Zoo, the San Diego Zoo, and the Cincinnati Zoological Garden. You may know other fine museums, zoos, and gardens. *Find the nearest ones to you and make an effort to visit them as often as possible. Post a list of those near you on the classroom bulletin board.*

### 7. How can we experiment at home?

We hear often of the investigations of scientists working with complicated apparatus in expensive laboratories. We may get the idea that it is impossible to carry on experiments without expensive equipment. It is possible to carry on many experiments with very simple apparatus. We may not be able to discover any important new truths which scientists have not known before, but we can learn very much for ourselves, and sometimes prove to our own satisfaction the solutions to many perplexing problems.

A home shop or laboratory requires but little space, and you can add to the equipment from time to time. An old table or bench with a top that can be scrubbed is the first necessity. A piece of sheet metal or a scrap of linoleum makes a good cover for such a work table. A small vise is useful. You will want a few tools—a hammer, screw driver, pliers, hacksaw, and perhaps an electric soldering iron. An outlet for connecting electric appliances is desirable. If you experiment with electric toys, a bell-ringing transformer can be attached to this outlet. You will want good light from a window or a properly shaded electric lamp. Most people want a bookshelf over the work table for keeping reference books, catalogues and apparatus not in immediate use. A stool or chair may be needed for convenience in working.

Other equipment will depend upon what your hobby may happen to be. Many simple scientific experiments can be carried on with apparatus from the home kitchen, the ten-cent store, or even from the basement junk box. Turn to pages 29 and 30 and look at the suggestions for experiments that you are able to do with very simple equipment. Some of the books in the reading list at the end of this unit will give many other similar suggestions.

Many of you know of the commercial sets sold for home experimenters in hardware stores and in the toy sections of department stores. These include combinations of pieces for making mechanical toys, chemistry sets, and electrical sets. Some now include cheap microscopes. The sets contain instruction books telling how to use the equipment. You can learn many things with these. Ordinarily, the apparatus contained in them is rather poor, and costs more than a similar amount of like material would cost if you knew where and how to buy it. In class you may be able to plan or put together a science kit of your own which will be much more serviceable. The advantage in the commercial sets is that they are already assembled and include many suggestions.

If you are interested in aquatic or sea creatures, you may like an aquarium. Perhaps you are used to hearing this word applied only to large institutions where fish are kept and exhibited. But your fishbowl is an aquarium too. Begin with just a small one until you have learned how to keep your fish alive under the conditions in your home. A simple aquarium can be set up in a straight-sided battery jar that will hold a gallon or more of water. This is better than the small globe-shaped fishbowls. Often the jars used for cells in home-lighting plants can be bought at a junk yard for ten cents each or at small cost. After they have been thoroughly cleaned, these jars make excellent containers for aquaria.

Plants of some kind can be grown in almost any situation. If you live in a heated city apartment with very dry indoor air in winter, you may like to start a collection of small desert plants.

Perhaps you would rather try a small balanced *vivarium* in which you grow plants under a glass cover so that the moisture inside is constantly controlled. (You can discover for yourself the meaning of vī-vâr′ĭ-ŭm if you remember that the same word base is used in such words as *vivify* or *revive.*) If you have a yard, there are almost endless possibilities in different kinds of plants. One girl, a friend of the authors, specializes in growing different kinds of gourds.

If you like to work with electricity, there are many small electrical appliances that you can build, such as telephones, telegraph instruments, doorbells, buzzers, burglar alarms, motors, and radio receivers. Almost any seventh-grade boy or girl is able to build a crystal radio receiver. This requires no electric current of its own, and will receive programs from stations within thirty miles of your home. Directions for making these simple receivers are included in nearly all of the radio books for beginners. If you are more ambitious, you can almost as easily, but with more expense, make a one- or two-tube set.

You know, of course, that you can learn many things about light and photography and some things about chemistry if you are interested in taking pictures. A simple box camera will give you a good start. You will want to turn your home workshop into a dark room for this.

It is now possible to buy an inexpensive microscope for home use. With this instrument you are able to become acquainted with the creatures that may live in a drop of pond

YOU CAN HUNT BIRDS WITH A FIELD GLASS IN A CITY PARK. THIS PICTURE SHOWS A CORNER OF BRONX PARK IN NEW YORK CITY.

or sea water, with the minute parts of insects, with the corpuscles in your own blood, and with many other things that were hidden from people for thousands of years.

Those who live on the edge of town or near a city park can learn to identify plants and birds. Begin with the trees that you find in your community, with shrubs in the park, or with cultivated garden flowers. If you like to hunt birds, an inexpensive field glass will help immensely. Keys for identifying trees, wild flowers, or birds are for sale in almost any book store. The titles of some good ones are contained in the book lists of the American Association for the Advancement of Science mentioned on page 24.

*Plan a science class hobby day on which members of the*

THOMAS ALVA EDISON WAS AN UNUSUAL SCIENTIST. TODAY YOUNG SCIENTISTS MUST HAVE MORE SCHOOL AND UNIVERSITY TRAINING THAN EDISON HAD.

*class make reports and show exhibits of science hobbies carried on outside of school. Post the program for these on the classroom bulletin board two days before the event is held.*

8. Who are scientists?

Perhaps if you do the things which we have just discussed, you will want to be a scientist, or perhaps call yourself a scientist, just as young people who take correspondence courses in detective work like to pretend to be detectives. Can you be a scientist on your own account with home equipment? Perhaps we had better say that you can be an amateur scientist, but not a professional.

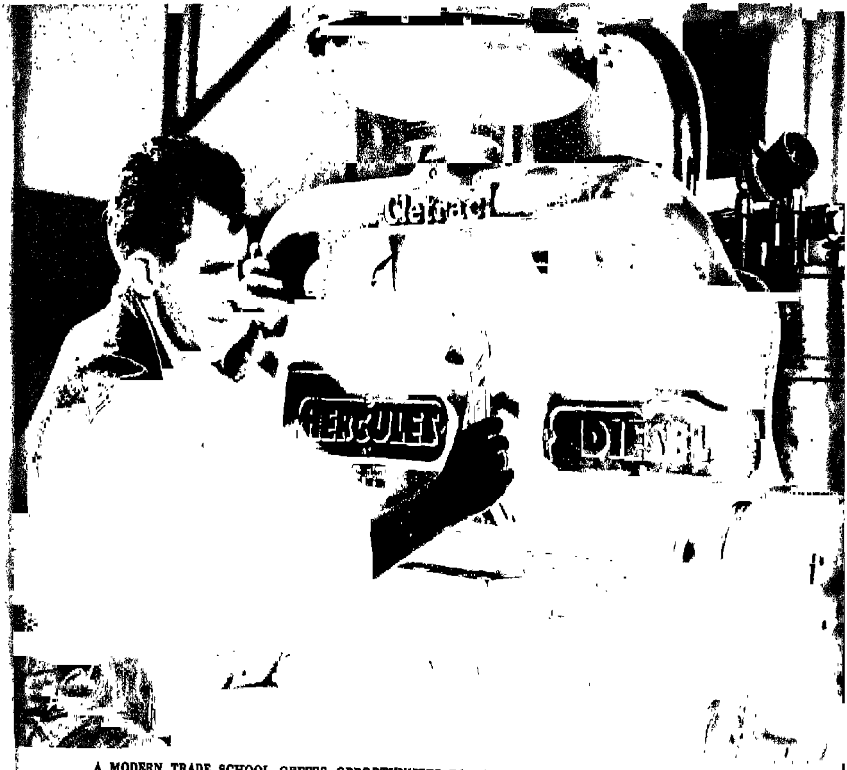
The knowledge and the methods of work which we now call science have become so extensive that it requires years of training to know very much about any small division of science. Most scientists today are trained in colleges and universities. Just graduation from a four-year college is usually not enough. Most of our professional scientists have graduate degrees. They are doctors of science, or doctors of philosophy. The abbreviations are D.Sc. or Ph.D. Physicians and surgeons are doctors of medicine, M.D. Graduate engineers have special degrees in engineering. To receive such distinction requires at least three years of graduate study beyond the work of the four-year college. Many of these men have had considerable experience in laboratories, hospitals, or on research expeditions.

Persons who advertise themselves as scientists, but who are without the training which we have described, are often frauds or imposters. Before trusting a "scientist," it is wise to find out what kind of training he has had and where. There are dishonest people, with good training in science, who misuse their knowledge to impose on others. Probably these are relatively few, so that a knowledge of the training of a man is a fairly good index of whether or not he is a scientist.

There are a few people who have not had the kind of college and university training usually expected of scientists who, by hard work and a great amount of study, have become respected scientists. Such men as Thomas A. Edison and Luther Burbank are naturally spoken of as scientists although they acquired most of their training outside the schools.

The scientist tries to find out new things about the world in which we live or to find new uses for those things about the world that are now known. The work is nearly always interesting and often fascinating. Perhaps you think that you would like to become a scientist.

To be a scientist you will need to have good ability to do



A MODERN TRADE SCHOOL OFFERS OPPORTUNITIES TO PERSONS WHO DO NOT WISH TO BECOME PROFESSIONAL WORKERS IN SCIENCE.

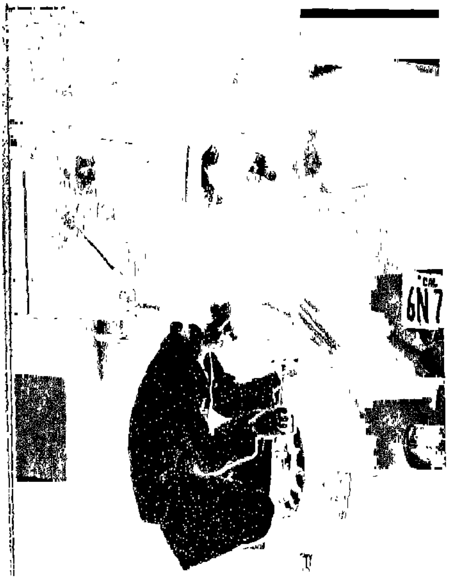
school work. Your work will need to be better than that of the average of your schoolmates. You will need to like the kind of things with which you expect to work as a scientist. If you wish to be a botanist, you must want to work with plants. If you want to be a surgeon, you must be concerned with the structures of living people. If you want to be an engineer, you must be interested in engines, machines, or electrical apparatus. Your marks in science courses, beginning with this one and running on through high school and college, should be high. If you make a poor record in high school and later on in beginning college, you will find it practically impossible to enter any medical school in the country, or most of the better engineering colleges. Those who enter these institutions will profit from good preparatory training.

Many kinds of scientific work require frequent use of mathematics. If you have an ambition to be a scientist, you will need to be able to do good work in mathematics. This should begin with your upper grade arithmetic or junior-high-school mathematics. You will need to do as much work as you can in mathematics in high school and continue this training in college.

A scientist needs to learn to be honest about what his experiments or observations show. Many of us would like to bend our thinking in the direction of the thing we want to prove or want to believe. The scientist must learn to accept what he finds whether or not it is the thing which he wants to find, or wants to believe. If you cannot learn to have this attitude, you will not make a good scientist. Perhaps you can begin to look at things in the light of what the evidence shows, instead of in the light of your own wishes. If you can do this, you will make a beginning in one very necessary kind of training which a scientist must have.

If you are keenly interested in the things of science, but for some reason do not care to become a professional worker in science, there are other things that you are able to do. You can learn many interesting facts for yourself, and can profit by some school courses in science. There are also

AUTOMOBILE SERVICING MAKES TRADE SCHOOL OPPORTUNITIES.



many occupations dealing with science applications that do not require the intensive training that is needed by the professional scientist. If you cannot be a professional engineer, you might succeed as a radio-service man, as an air-conditioning worker, as a refrigerator-service man, or as a garage mechanic. If you cannot be a botanist, you might become an expert gardener, or a florist. We have so many uses for the findings of science today that almost anyone who is interested can find some employment in work that is connected with scientific development.

### THINGS TO DO

1. Make a table of good and bad happenings for yourself. Fill in this table with the important things that you remember as happening to you for the past two weeks, noting only those things that seem unusually good or those that seem to you unfortunate. Break a cheap mirror. Keep your good and bad happenings record for two weeks more. Report whether you find any difference in the list for the two weeks after mirror breaking and that for the two weeks before.
2. Bring to class a piece of modern advertising which seems to try to build up a superstitious belief in the value of some advertised product without presenting good scientific evidence, which will justify its claims.

THERE ARE TRADES FOR GIRLS TOO.

3. Can you describe some problem which you could solve by keeping accurate records of observations made for several days or weeks?
4. Make a list of new science books that you would like to have in your school library. Ask the teacher to check this list with you.
5. Arrange to have a trained scientist, physician, or engineer in your community visit the class and describe the training which workers in his field must have.
6. Make a list of the parents of pupils in your science class who have been trained as scientists. Do not forget the mothers of pupils. Many women have good scientific training.
7. Ask pupils in your class who have science sets like those described on page 28 to bring these to class and demonstrate what can be done with them.
8. Make a list of science books which you would like to purchase for your own library. Ask your teacher to tell you which of these you can read.
9. Examine ten different science magazines. Which of these do you prefer to read? Which does your school have? Ask your teacher to suggest which are most likely to be reliable. What reasons does the teacher give for his suggestions?

### SOME THINGS TO REMEMBER

1. Instead of accepting a coincidence, or a superstitious explanation, the scientist tries to find a natural cause for each happening and to prove with evidence the relationship between the apparent cause and effect.
2. Much modern advertising tries to establish superstitious beliefs in the value of trade-marked articles.
3. It is possible to check a "tall story" in terms of the known facts, or to submit the story to experiment to

prove its truth or falsity. Often it is necessary to consult experienced persons in order to reach a conclusion.

4. Many scientific discoveries are as marvelous as fairy tales. We trust the honesty of the scientist, or the reliability of the publication making the report, in determining whether we shall believe in the discovery.
5. The scientist tries to prove solutions to problems by trying out processes under controlled conditions.
6. Much scientific work is done by making careful and exact observations which are recorded for making comparisons.
7. Measurement is necessary for making exact observations.
8. A control is often needed to check observations.
9. It is possible for us to get evidence to prove the solutions to many of our homely everyday problems.
10. Many answers to scientific questions can be found in reliable books and magazines.
11. There are lists of science books that can be used as guides in selecting reliable books.
12. Much reliable scientific information can be secured from agencies of the Federal Government in Washington, D. C.
13. There are many kinds of scientific activities that can be carried on with simple and inexpensive equipment at home.
14. Many years of school experience are necessary to train a science specialist.
15. Persons who claim to be scientists and have little school training are often frauds or impostors.
16. It is possible to learn many things in science and to have scientific attitudes without being a highly trained specialist.
17. Anyone who wishes to be a scientist will have to learn to be absolutely honest in all observations.

Chase, Stuart and Schlink, F. J. *Your Money's Worth.* The Macmillan Company.

Disraeli, Robert. *Seeing the Unseen.* John Day Company.

Leisure League of America, *Leisure League Little Books:* "What to Do about Your Invention"; "Tropical Fish"; "Photography For Fun"; "A Garden in the House"; "Discover the Stars." Leisure League of America, Publishers.

Lynde, C. J. *Science Experiences with Home Equipment.* International Textbook Company.

Neblette, C. B., Brehm, F. W., and Priest, E. L. *Elementary Photography.* The Macmillan Company.

Watkins, R. K. and Bedell, R. C. *General Science for Today.* (Revised.) Chapters 27 and 28. The Macmillan Company.

Wylie, C. C. *Our Starland.* Lyons & Carnahan Company.

# UNIT
# TWO

## UNIT TWO

# Learning About the Earth Beneath Our Feet

### WHAT THIS UNIT IS ABOUT

Have you ever wondered about the spot of earth beneath your feet? As you stand on a pavement, do you wonder what is under the pavement? When you look at the grass in your lawn or in the city park, do you have questions about why the grass grows so well there and not so well in other places? When you sift the sand through your fingers at the beach, do you ask where the sand comes from? In looking at the pale, cold moon on a clear night, do you wonder why many beings live on the earth, while the moon is without life?

With modern means of travel, we are likely to begin to believe that after all the earth is not so big. How large is the earth? What can we find out about the dirt under our feet? What is soil? How does it happen that things can live on the earth? Can we do anything to the surface of the earth to make it a pleasanter place in which to live? These are some of the things that the material in this unit may help you to find out.

You should be better able to enjoy a walk through the park, or along a country lane, if you know more about the earth under your feet. You might be able to have a better garden or lawn if you knew what makes a suitable soil. Perhaps you can have a better trip to the beach or the mountains if you know about sand, pebbles, and rocks.

# Learning About the Earth Beneath Our Feet

## UNIT PROBLEMS

1. How big is the earth?
2. What can we learn about the earth by looking at the outside?
3. How thick is the earth's crust?
4. What is soil?
5. Why is the earth a suitable place in which to live?
6. What is the difference between good and poor soil?
7. How does water get into the soil?
8. Where do rocks, sand, and gravel come from?
9. What is clay?
10. What kinds of soils make good lawns and gardens?
11. How are roads made over the surface of the earth?
12. How are good house foundations made?

## THE EARTH AS WE SEE IT

If you stand outside on a clear dark night and look up at the uncounted stars spread across the depth of the sky, you are likely to be lost in helpless wonder. What are these points of light? How do they happen to be in the sky? How big are they, and how far away? What do they have to do with you? Next morning you come out of the front door hurrying on the way to school. Do you wonder about the earth upon which you walk? The earth and its surface crust are so much a part of our daily living that we take them for granted and often forget to ask questions about them. These very things that

IT IS DIFFICULT TO GET AN IDEA OF THE EARTH'S SURFACE BY STANDING IN ONE SPOT. IN ILLINOIS MANY FIELDS ARE PLANTED IN GRAIN.

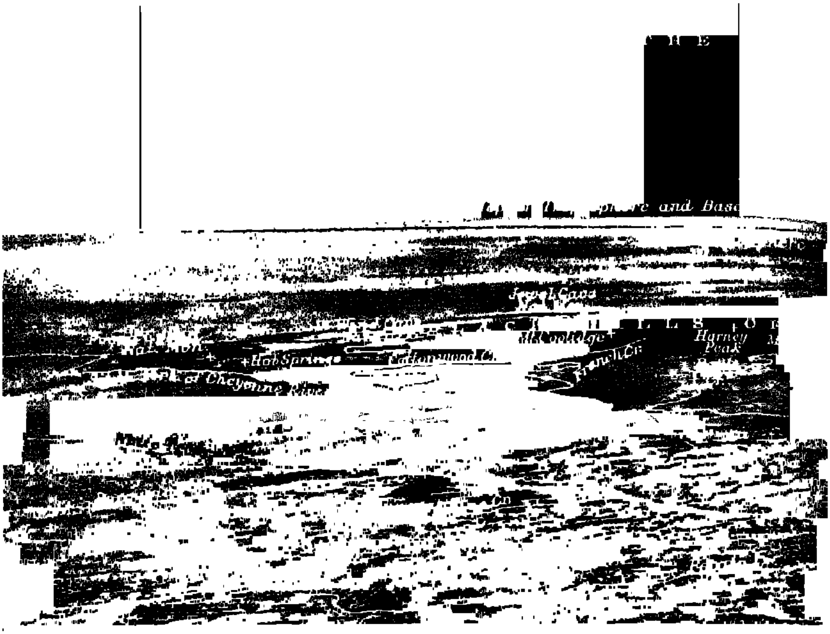
seem so natural to us make it possible to exist on the earth's surface. What can we find out about the top crust of the earth? Is there anything that we can do to make the surface of the earth contribute more to our own living?

## 1. How big is the earth?

It is hard to get an idea of the earth by standing on one spot and looking at it. A part of this difficulty is due to the

CONTRAST THIS PHOTOGRAPH OF YELLOWSTONE FALLS IN WYOMING WITH THE FLAT ASPECT OF THE LANDSCAPE PICTURED ON THE OPPOSITE PAGE.

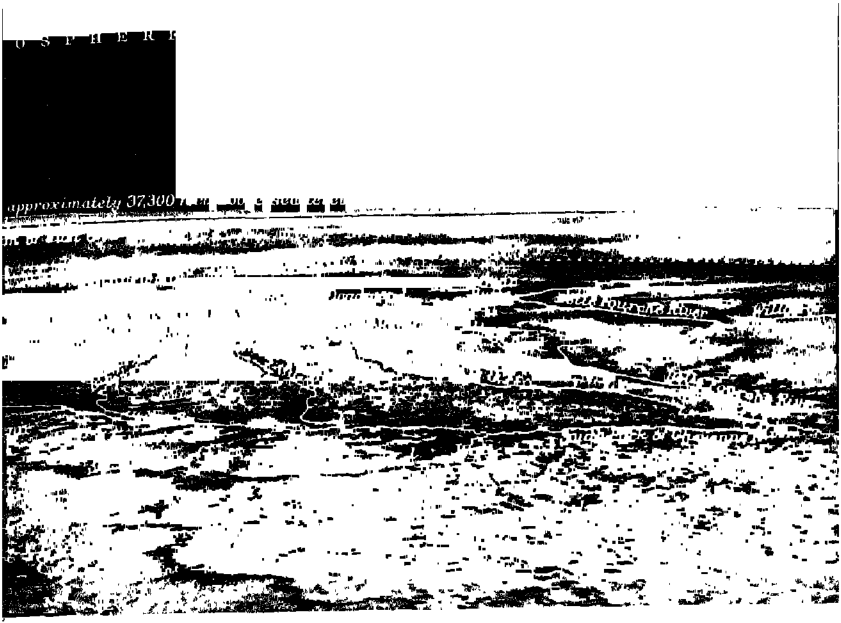
fact that it is possible to see such a small part of it at any one time. As you have heard all of your life, the earth is shaped like a large ball. If you look out over a farm or a golf course, this does not seem to be true. Except for hills and valleys, the earth looks flat. If you read the tales of our ancestors, you will find that many of them believed that the earth was a flat surface and that, if a traveler went far enough, he would fall off the edge.



THIS PHOTOGRAPH WAS TAKEN FROM A BALLOON 14 MILES ABOVE THE SURFACE OF THE EARTH.

If you were sufficiently high above the earth, you would be able to see a part of the curve of its surface. Until very recently no one has been able to get up high enough to see this. Other evidences have been given to prove that the earth is ball shaped. Some of these are: (1) The sky appears curved and seems to come down to the earth at the horizon. (2) The shadow of the earth on the moon at the time of an eclipse is curved. (3) If you start to travel in any given direction and travel long enough, you come back to the starting place. In other words, you go around the earth.

Just recently some daring men have been able to get up far enough above the surface of the earth to see its curving. In our country, Captain Stevens and Captain Anderson went up in a large balloon nearly fourteen miles above the surface of the earth. They could then see enough of the earth's surface at one time to see that it is curved. Photographs were made



IF YOU EXAMINE THE PICTURE CAREFULLY YOU WILL SEE THE CURVATURE OF THE EARTH'S SURFACE.

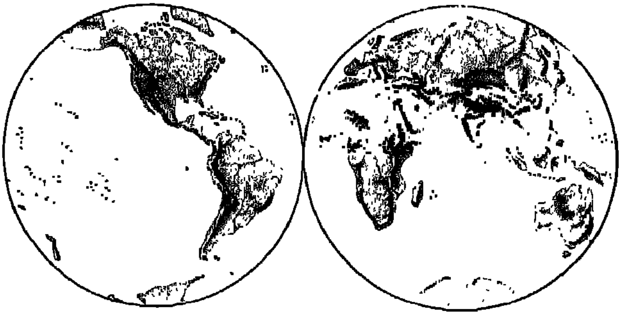
on this famous flight. One of these pictures is shown above. If you examine the picture you will be able to see the curvature of the surface of the earth.

The earth, measured at the equator, is just about 25,000 miles around. The equator is an imaginary belt around the earth halfway between the north and south poles. If you will examine the school globe, you will find the poles and the equator marked on it. If you could drive the family automobile around the earth at the equator, the trip (driving at the rate of fifty miles an hour for ten hours each day) would take about fifty days. A large city seems to be only a spot on the earth's surface. The printers' marks on maps of the world exaggerate the sizes of cities because it is impossible to make any mark on a small scale map which is not too large to represent the actual size of the city. A 160-acre farm is, comparatively, smaller than a pin prick on the earth's surface.

The area of the earth's surface is estimated to be 50,265,600 square miles. *Find in the school encyclopedia or atlas the estimated area in square miles of the state in which you live. What part of the surface of the earth is formed by the area of your state?*

| | | |
|---|---|---|
| Maine | 33,040 sq. mi. | .0006 of the earth's surface |
| Missouri | 69,415 sq. mi. | .0014 of the earth's surface |
| California | 158,297 sq. mi. | .0031 of the earth's surface |

How many miles is it across your state from east to west? How long does it take to cross the state in an automobile driving at the rate of forty-five miles per hour? If it were possible to drive an automobile around the earth at the equator, how many hours would it take to drive around the earth, driving at the same rate? Why can't you drive an automobile around the earth at the equator? *Find on a good globe the various things that interfere with driving around the earth in an automobile.*



A FAR LARGER PART OF THE EARTH'S SURFACE IS COVERED WITH WATER THAN WITH DRY LAND. THE OCEANS COVER ABOUT THREE QUARTERS OF THE EARTH.

### 2. What can we learn about the earth by looking at the outside?

Suppose that we examine a part of that portion of the earth's surface which we see for ourselves. What can we see? If you look down at the ground in the schoolyard or in the backyard at home, you will see soil or dirt. In large amounts we speak of this material as land. The farmer in buying a farm speaks of buying so much land. Here and there you can find large rocks rising out of the land. Sometimes piles of rock are large enough to become hills or mountains.

Besides the land which we can see, there is water on the surface of the earth. If you travel far enough in any direction you will finally come to a place where the earth's surface is covered with water. As a matter of fact a larger part of the earth's surface is covered with water than with dry land. The large oceans cover nearly three fourths of the earth.

Another part of the earth's surface that we do not see directly, but which we can feel and examine in many ways, is the layer of air that surrounds the whole earth. The air is just as much a part of the earth's outer covering as the soil and water. This layer is thought to be at least two hundred miles thick and soon thins out into the emptiness of space.

We can see by looking at small parts of the earth's surface in many places that the earth is surrounded by a layer of air; that much of the surface consists of land; that in many places enormous masses of rock are thrust up through the land; and that much of the surface is covered with water. Added to this we observe that much of the land surface is covered with living plants. Among these plants can be found a great variety of living creatures.

*Take a walk to some place away from tall buildings and pavements where you can look out at the earth. A city park will serve, if you live in the city. Take with you a pencil and* *a notebook or piece of paper. List all of the facts about the surface of the earth that you can discover by looking at it. Bring the list to school. Make a blackboard list of all the facts that the class gathers by putting together all the things in the lists of several pupils.*

### 3. How thick is the earth's crust?

The outer part of the land which we see is often called the earth's crust. If we dig down through the outer softer layer on top, we soon come to solid rock. In some places the rock sticks through and no digging is necessary; in other places it may be many feet to the rock. This outer rock is also con-

THE HIGH MOUNTAINS OF GOLDEN CANYON, CALIFORNIA, ARE MERE WRINKLES IN THE EARTH'S SURFACE AS COMPARED WITH THE TOTAL SIZE OF THE EARTH.

sidered as a part of the crust. It is believed that the interior of the earth is some very hard rigid material, probably iron and nickel. How far it is necessary to dig to get to this substance is not known exactly.

WHAT PROCESSES ARE STILL ACTING TO CHANGE THE NATURE OF THE MATERIALS SHOWN IN THIS PICTURE?

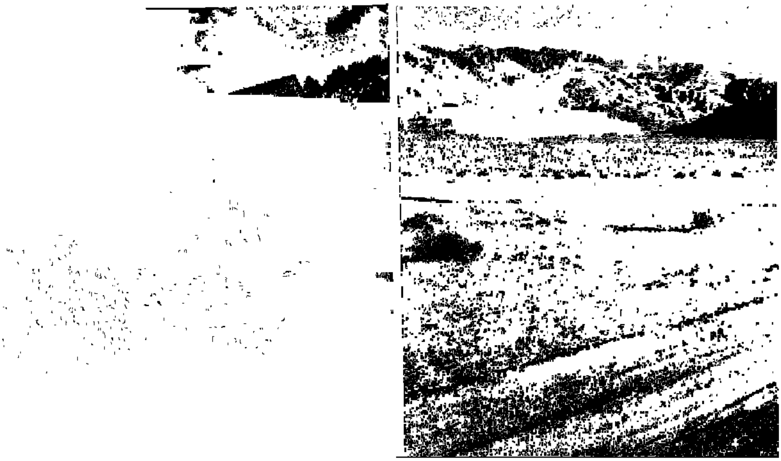
It is possible to get some idea of the thickness of the rock crust in another way. The surface of the earth is not smooth. If you travel along the highway, there are mountains and valleys. In places there are great mountains. In other places there are holes or deeps. Most of these are filled with water. The greatest deeps on the earth's surface are beneath the water of the oceans. How high and how deep are these places? The highest mountain known is Mount Everest. It is about five and one half miles high. The deepest holes in the ocean are about as deep as this mountain is high. This would make the difference between the greatest height and the deepest hole in the crust about eleven miles. At first this seems to be a very large amount. Compared to the size of the whole earth, mountain ranges and deep holes in the ocean floor are only small wrinkles. The ridges in the skin of an orange are larger by comparison than mountains on the earth's surface.

### 4. What is soil?

Nearer to us than mountains and ocean deeps is the earth under our feet. Sometimes we speak of the loose surface layer upon which we walk as dirt. Perhaps a more polite term is soil. What is soil? The greater part of the soil is ground-up rock. This doubtless seems reasonable to those of you who live in rocky and hilly country or near streams that carry sand and gravel along their beds. To those of you who live on plains or prairies with not a rock in sight this may seem farfetched at first. At some time every part of the earth's surface was covered with rock. The soil has been formed by breaking up this rock material. Rocks are now in the process of being broken up into soil by the various forces of nature.

The various forces and materials, which we speak of as weather and climate, are the mills that have done much of the grinding. The movements of the oceans scour the rocks along the shore. As soon as small pieces break off these help to scour the surface of the rock that remains. Rivers cut into the surfaces over which they flow. In colder regions, rivers of ice called glaciers grind the rock in their beds. Winds pick up small particles and carry them to other spots or drive them against exposed rocks to wear away new pieces. The heating and cooling of the rock surfaces with the following

WHAT CONDITIONS NECESSARY FOR AN ABUNDANCE OF LIFE ARE PRESENT IN ONE OF THESE PICTURES THAT ARE LACKING IN THE OTHER?



WHAT MAKES THE DIFFERENCE BETWEEN GOOD SOIL AND POOR SOIL?

expanding and contracting of the substances tend to crack larger stones into smaller ones. Rains dissolve certain chemicals from the crust. The solutions formed often react with other chemicals in rock so that further wearing away takes place. All these processes tend to break up the older rock crust of the earth into finer rock particles, gravel, sand, and clay.

Rocks, gravel, sand, and clays are often white, yellowish, or red in color. Many soils are black, gray, or brown. The darker color of the soil is largely due to the presence of decayed matter from dead plants and animals. This can be seen in a wood lot where leaves from the trees have been undisturbed for several years. The top layer of soil just under last year's leaves will be leaf mold and black in color. Dig down a foot or so and a lighter colored soil will be found which contains less decayed plant material.

*Gather as many different samples of soil as you find in your neighborhood. Dry these and separate them as well as* *you can. What is in these samples? In what ways are the samples different? What makes the difference in the samples?*

### 5. Why is the earth a suitable place in which to live?

The soil on the earth interests us because living things grow in it. A bare rock exposed to the constant glare of a summer's sun is not a place to stay for very long. Soil is a better substance for living things than a bare rock. Why? One of the reasons is that the soil is porous, full of small holes. Through the pores, or holes, in the soil air and water circulate. All living things must have water and oxygen from the air. This raises the question of the conditions on the earth which seem to make possible the kind of life which we know.

Of course the sun is too hot for living creatures. Even from its vast distance, it radiates too much heat for living things on the earth, unless they have some protection. It is the air on the earth that actually supplies this protection for animals and plants. A certain amount of heat is necessary for life. Too great an amount or too little interferes with life. The layer of air about the earth, which helps to temper the heat from the sun, makes life possible on the earth.

All living things that we know contain water. The earliest living things on the earth are thought to have grown in water, probably in the sea. Today most water on the surface of the earth contains living organisms. Under the microscope, a single drop of pond water is found to have in it many very small moving creatures. Water is a part of all things that live. It is also the means by which food materials are carried into all the parts of living plants and animals. Foods to become useful most be dissolved in water.

A certain amount of heat, water, and air are necessary for life. Where these are supplied in the right amounts there is abundant life on the surface of the earth.

When we think of soil in connection with living things we most often think of the plants that grow in the ground. These plants must have water and air just as must all other things that live. The air comes from the atmosphere about the plant. The soil contributes something besides the water contained in its pores. The plants must have certain building materials other than the water and carbon dioxide from the air. (See also pages 54-55). These building materials are to be found in the soil, dissolved in small quantities in the soil water. They are taken into the plant along with the water which comes in at the roots. Since all animals either eat plants, or animals that live upon plant material, we can readily see that we depend upon plant life for our food materials. Many plants must have soil in which to grow. In this sense all of us are indeed creatures of the earth.

### 6. What is the difference between good and poor soil?

We know when we think about it that many plants grow in some places and very few grow in others. Part of this is due to the general conditions which we call climate, and not to the soil. Few plants grow in deserts. However, desert places can produce a multitude of plants if enough water is provided. Two fields lying alongside one another produce different amounts of plant growth. Your lawn may be covered with fine grass. Your next door neighbor's may be as bare as the street. Both are in the same general climate. Perhaps the difference is due to differences in the soil or to ways in which the soil is treated.

A good soil must be loose and open enough for air and water to circulate through it. The roots of plants must be able to get down into the earth. A brick is made of earth materials. Although most bricks are open enough for some air and water to get through, they do not make good plant beds.

Plants do not grow well in a packed and beaten roadway. The farmer tries to improve the condition of the top layer of the soil by plowing it and breaking the large clods into finer bits with a harrow or some other tool.

Good soils contain comparatively large amounts of the soil materials most needed by the plants as building materials for their various parts. Poor soils contain smaller amounts of these substances. Three kinds of substances are needed by plants in considerable quantities. These are compounds containing the chemical elements (see pages 225-228) nitrogen, phosphorus, and potassium. Compounds of other elements are needed in smaller quantities. Some soils contain enough of two of these compounds and are lacking in one of them, and so on in varying degrees.

Under natural conditions the plants in a given place live and die there. The dead parts fall on the earth and the substances taken from the soil through their roots go back into the soil. In this way a good soil would almost always continue to be a good soil.

If plants grown on a piece of land are taken away for use, the materials removed from the soil by the plants are not returned to the soil. As a result, the soil on this piece of ground becomes poorer and poorer from year to year as the crops are taken away. Removing the plants also exposes a piece of land to washing from rains and the tiny streams which form on the ground during a rain. This tends to carry away the needed parts of the soil.

We can understand how all this works in a small backyard garden. To make the garden in the first place we dig up the top layer of soil. In doing this we dig up and destroy the plants there that we do not wish to continue to grow in the garden. Suppose we wish to grow lettuce, beans, and tomatoes. We plant these in rows and hoe out all other kinds of plants.

REMOVAL OF VEGETATION FROM THE SOIL TAKES AWAY ITS PROTECTION. THE PICTURE TO THE LEFT SHOWS THE EFFECTS OF THE PLOW IN A DRY CLIMATE; THAT TO THE RIGHT THE EFFECTS OF THE PLOW ON A SLOPE IN A MOIST CLIMATE.

When the lettuce plants are grown we cut them off and eat nearly the whole of them. Almost none of these go back to the soil. We eat the fruits and seeds of the ripened beans and tomatoes. In the fall we cut off the bean and tomato vines and burn them to get them out of the way.

The summer rains wash away part of the top soil as there is nothing between the rows to cover it. In the winter, if the garden is left bare, more soil is lost. If our garden is on a hillside, we can see the little ravines that form. In a single season the top edge of the garden becomes noticeably lower than the edge of the lawn above. If we continue to garden in this fashion, tomatoes and beans will be fewer from year to year. The lettuce plants will be smaller and the tomatoes dwarfed.

After a while the soil of the garden becomes too poor to be worth working. We would now proceed to make a garden in a new place. The old garden will look bad and the rains will wash it full of gullies. Suppose that our yard is small and we cannot find another place to garden. It would be better to try to keep the soil in good condition from the beginning. To do this, we try to add materials to replace those removed by the plants that we have used. These materials that we add to the soil are called fertilizers. Sometimes decayed plant and animal wastes are added and sometimes ground-up chemical substances are used. In addition we plant a fall crop of some kind to keep the top soil of the garden covered during the winter when we do not grow garden crops. In this way we can keep our garden going for a long time.

*From books and bulletins on gardening, find out the kinds of soils needed for vegetable and flower gardens. How can soils be improved for growing plants? Can you explain why these treatments improve the soil? Make a four-minute report to the science class. An exhibit of materials will help your report.*

### 7. How does water get into the soil?

Good soil is dependent upon its water supply. There must be enough water for the land but the soil must hold it during dry periods. Surplus water must drain away, as many plants do not grow in swampy land. Given a proper water supply and drainage, much of the soil over the surface of the earth can be called good soil.

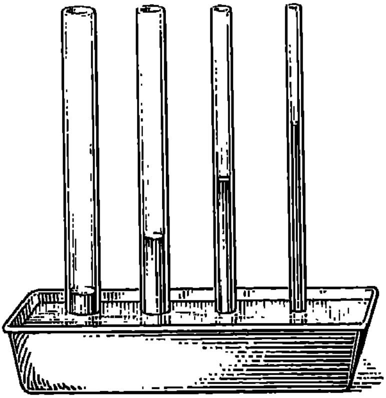
Water first gets into the top layers of soil from rains. If the top of the earth is loose and porous, much of the rain water soaks down through it. If the top is packed and hard, more of the rain runs off into near-by ditches and creeks. The rain water that soaks down through the soil is stored in the pores of the soil very much as water that is poured on a dry sponge may be held in the pores of the sponge. *Get a large sponge and see how much water you can pour into it if you pour slowly, a little water at a time.*

The sun and wind dry off the top of the soil by the process which we call evaporation. When this happens the soil water rises from below through the pores to the upper layer. The process by which this goes on is called *capillarity* or *capillary attraction.* If a small tube is plunged into water, the water will rise higher in the small tube than the level of the water around it. This is due to capillary attraction. You can see this same thing happen in a lamp wick. *If you will suspend a thick wick in a pan of water, water will rise to the top of the wick through the pores in the cloth.* Water rises in the soil very much as water will rise in the wick, as long as there is a supply of water in the lower layers of the soil.

Most often we think of the upper layer of the earth's crust, in which we find the roots of the shallower-rooted plants like grass and the garden vegetables, as the soil. Below this soil is found the subsoil. *This can be seen by digging a hole a foot or two deep and examining the material at the bottom of the hole.* The nature of the subsoil varies in different places. Sometimes it consists of clay. In other places it is made up of broken rock, gravel, or sand. The kind of subsoil under the upper soil layer has much to do with the reserve water supply for growing crops.

## 8. Where do rocks, sand, and gravel come from?

The great masses of rock which jut out from the sides of mountains were perhaps parts of the original outer shell of the earth formed as the earth cooled, a very long time ago. Perhaps they were formed later from layers of earth, plant, or animal material deposited in water and turned into rock by heat and pressure. Some of these great rock masses have been broken up into smaller



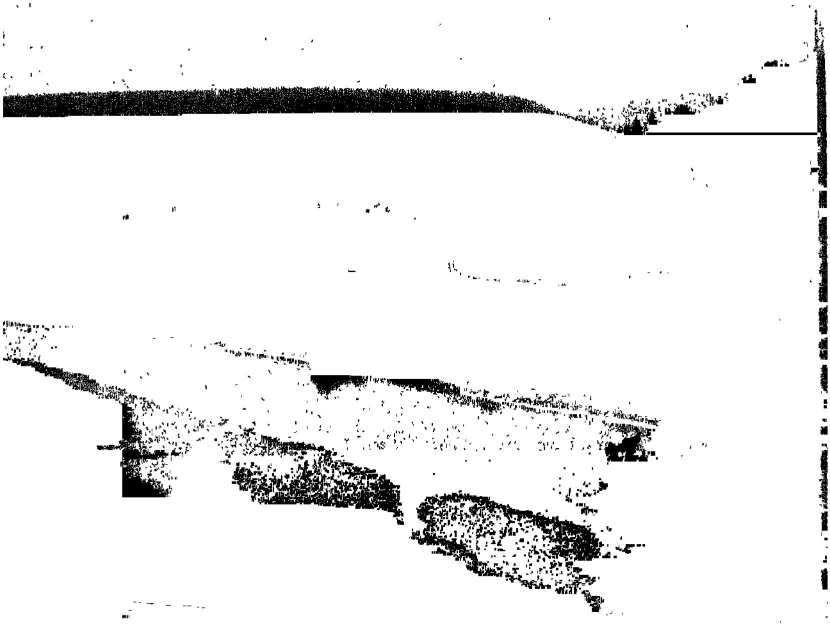
WATER RISES THROUGH THE PORES IN THE SOIL IN THE SAME WAY THAT WATER RISES IN CAPILLARY TUBES.

pieces by the processes described on page 50. The smaller earth material rolls down the hillsides to fill the lower spaces or is carried down by streams and glaciers.

Along the edges of streams, lakes, and the seashore, we find sand, gravel, and small rocks uncovered. Often we call these gravel bars, sand bars, or beaches. In most other places these coarser materials have been covered with others finer or mixed with some more finely ground. In a great many subsoils the material covering the coarser rock substances is clay, or a mixture of clay and sand.

*Visit a near-by stream bed. What kind of materials do you find along the edge of the stream? Can you find a bar extending out into the stream? What kinds of earth materials make up this bar? Gather samples and label them correctly for the science class museum. Can you find out where these different materials came from? How did they get to the bar or to the edge of the stream? If you live near the sea coast*

ROCK MATERIALS ARE DEPOSITED AND UNCOVERED BY STREAMS. WHAT BECOMES OF THE SOIL?



*or the shore of a large lake, try this same exercise at the seashore or lake side.*

BRICKS MADE OF CLAY ARE SHAPED AND DRIED IN THE SUN.

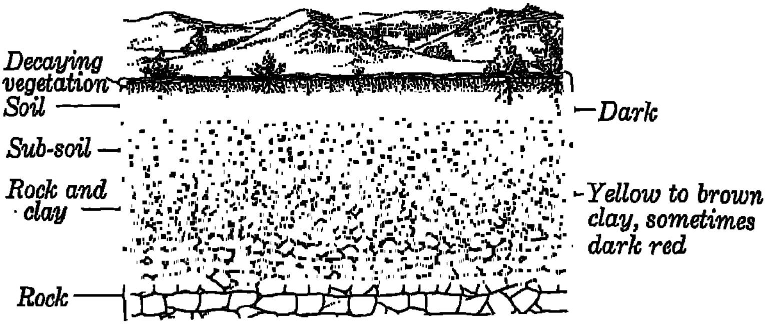
### 9. What is clay?

Clay is formed from the breaking down of the earth's crust. The particles are very finely ground. If a sample of clay is dried and broken up, the particles can be examined with a hand lens and compared in size with fine sand grains. Most clays are sticky when wet. If the wet clays are dried, they tend to become very hard. In some places sundried bricks are used for making buildings. The colors of the different kinds of clays are due to other rock materials or to plant and animal matter mixed in with the clay. Red, yellow, and tan clays most often get their colors from iron compounds in the soil. Darker clays or gray clays usually contain decayed plant and animal materials.

Clay can hold a considerable amount of water. When it is wet, water does not pass through it very rapidly. If clay is on top of the surface layer of the soil, it bakes into a very hard crust or into hard lumps. For these reasons a clay top soil is not very good for raising plants.

### 10. What kinds of soils make good lawns and gardens?

You have learned a few things about soil in your discussion of how it is formed. It should be remembered that its usefulness in a particular place for your own growing purposes

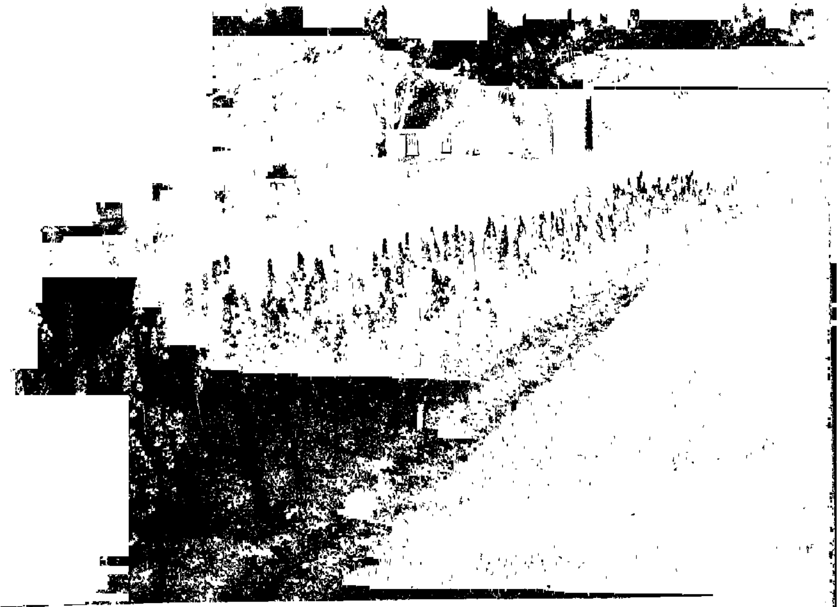


THE DARKER AND DEEPER THE TOP LAYER OF SOIL, THE BETTER THE SOIL FOR GARDENING. GRAVEL IN THE LOWER SUBSOIL INDICATES GOOD DRAINAGE.

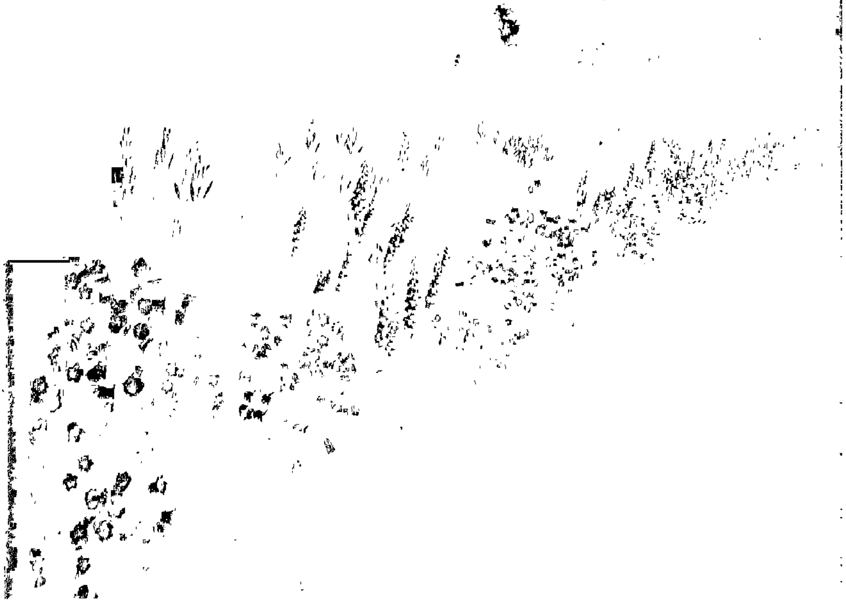
depends largely on the kind of subsoil underneath. If the subsoil is gravelly and too porous, water from rains passes through it and too little is left to feed the plants in the soil above. If the solid rock is too near the surface, the soil above is likely to bake and dry too readily in periods between rains. A tight clay subsoil may be too poorly drained for many kinds of plants. For the ordinary lawn or garden the best kind of subsoil is probably a mixture of sand and clay. Sometimes this kind of mixture is called a loam.

The best growing soils are begun with a clay loam. Large amounts of decayed plant and animal materials have been mixed into the top layer. A name for this plant and animal material is organic matter. The farmer calls it humus. In most cases the greater the amount of organic matter in the soil, the better the soil. Usually the color of the soil indicates the amount of this material in it. Most soils having much organic matter are dark, and are good for gardening. If the dark layer is thick the soil is better than if it is thin.

The effect of the organic matter is to increase the water-holding power of the soil. It becomes more nearly like a sponge. This also permits air to circulate through the soil. Roots may penetrate more readily, for the humus helps to



IT IS WORTH WHILE TO IMPROVE THE SOIL FOR GARDENING. THE GARDEN BELOW SHOWS THE RESULTS OF FERTILIZING THE SOIL. THE SOIL OF THE ONE ABOVE WAS UNIMPROVED.



keep the clay from sticking together. If the upper layer of a soil containing a good supply of humus is broken up by frequent cultivating, the rapid evaporation of water from the surface will be checked. This saves moisture for the plants in dry weather.

A poor top soil may be improved so that better lawns or gardens are possible. If the soil is too sandy, organic matter should be added. It is even possible to mix some clay and humus with such a soil. The organic matter can be obtained from animal manures from stables and barnyards, or from decayed leaves, or straw, or similar plant substances. If the soil is clayey, sticky in wet weather and hard in dry, it may be enriched by adding the same kinds of organic materials. Sand *is also useful on clay soils. If sand cannot be easily* found, sifted coal ashes will help.

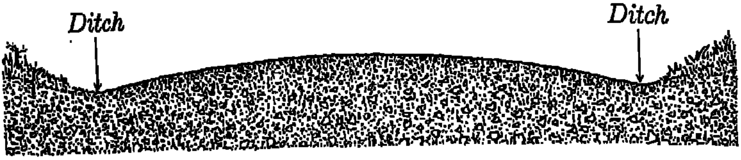
The animal manures add some of the needed building materials used by the plants. If more are needed, these can be added along with the organic matter in the form of chemical fertilizers. Almost any top soil can be built up until it will grow good plants. On a big farm it may cost more than the crops are worth. For a small lawn or garden it may be desirable. If the subsoil is very heavy clay or rocky or gravelly, the improved top soil may not make it possible to grow plants very successfully. However, if the subsoil is gravelly or sandy, and if a large water supply can be had cheaply, plants can be grown by very frequent watering.

*In some convenient place dig a hole about two feet deep. Examine the earth materials taken out of this hole. What changes take place in these materials as you go down? How deep is the top soil? How far down do you need to go to get to the subsoil? Do you find sand, gravel, or rocks in the hole? What kinds? How deep in the soil do you find plant roots? Do you find any other living things in the soil taken from* *the hole? What? Is the soil at the spot where you have dug the hole good or poor for growing plants? Can you find some way to prove your answer?*

## 11. How are roads made over the surface of the earth?

We are most concerned with the surface of the earth, with its soil and its subsoil, because of the things which live and grow in it. However, we may well be concerned about the earth in other ways. The nature of its surface determines largely how readily we can get from one place to another. Our earliest roads were probably narrow footpaths or may have followed the paths made by larger animals. This kind of road works very well when people have to go only short distances and do not have heavy loads to carry. As popula-

GOOD SOIL FREQUENTLY MAKES VERY POOR ROADS.



A ROAD IS OFTEN CROWNED IN ORDER TO OBTAIN EFFECTIVE DRAINAGE.

tions increase, move over greater distances, and trade with one another in bulky goods, better roads become important.

Other than trails and footpaths, the rivers were probably the great highroads of the past. They are nearly always open, and it is possible to move great loads over them without too great an effort. Not all the surface of the earth can be reached from the rivers, however. To get back into the interiors of the great plains other kinds of roads are needed.

In many ways a soil that makes good material for gardening makes a poor road. A dry road is usually better than a wet one. A soil that bakes hard on top makes a good road when it is dry. It is highly desirable that the subsoil drain the water away quickly. A rocky or gravelly subsoil would be a good one over which to build a road. Some of the worst roads in the United States, before the day of paved automobile highways, were in the great farming regions of the Middle West where the soil is the best for raising farm crops, but very poor for natural roads.

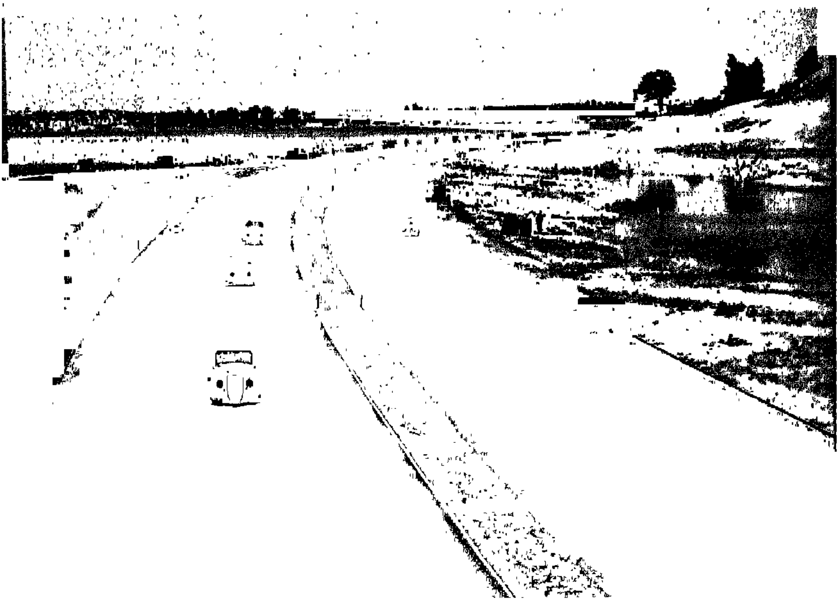
Many people who live on farms and many children who go to rural schools still travel over ordinary earth roads. These are very dusty in summer and so muddy in early spring that it is sometimes difficult to get a farm wagon over them.

As a garden soil can be improved, so a dirt road can be made better. The most important idea in making a good earth road is to drain the water away. To do this the road is graded so that it has a somewhat rounded crown. See the diagram on the opposite page. A ditch on each roadside carries the water away as it runs off the top. The ditches must have a fall in the direction of some near-by stream which carries the extra water away rapidly. If the surface of the road is kept dragged down and the holes filled, so that water does not collect in spots to form mud holes, the road will be free of bumps.

In many places a supply of natural gravel is found near a road. The gravel should be spread over the top of the graded road to form a hard surface which sheds water, and to make a much better top over which to travel. If the earth of the road has a considerable body of clay in it, it tends to bind the gravel together. In many modern roads, a tarry or asphalt substance is spread over the gravel to bind it.

The gravel road also is subject to the various breaking-up agencies of the weather that continually tear at the earth's surface. In climates where winters are cold the damp soil under the gravel freezes. In the spring the thawing softens

COMPARE THIS MODERN PAVED ROAD WITH THE UNIMPROVED EARTH ROAD SHOWN ON PAGE 63.



the ground underneath. This freezing and thawing breaks up the road foundation and the road tends to go to pieces. Gravel roads need to be constantly repaired to be kept in shape.

Roads can be paved with stone or with brick. Such roads are as good as the foundation underneath. In places where the subsoil drains readily and has in it rock and gravel, these roads hold up well. In other places some kind of foundation must be made under the paving.

One of the older types of roads with a foundation constructed underneath is the macadam road. In this kind broken stones are used. The top soil is taken away and a layer of heavy stones put in to make a foundation. Layers of smaller stones are put on the top to make the surface. Some of the older roads built on this plan are now covered over with asphalt.

Many of our present roads are made of more or less continuous slabs of concrete. For these the bed is graded very much as it is for an earth road. The bed is raised and somewhat curved so that the water will drain away from the earth foundation. Enough earth is taken out of the center of the roadbed to make room for the slab. The concrete is really an artificial rock which can be molded to fit the place where it is wanted. It is made of a mixture of broken stone, sand, and cement. When the cement is mixed with the sand and stone and wet with water, it hardens to form what we call concrete.

Concrete-slab roads hold up very well if the earth foundation underneath lasts. Floods sometimes wash the foundation away. The freezing and thawing sometimes affect the foundation of earth so that the slab becomes broken. In very hot summer weather the concrete may expand enough with the heat of the sun to buckle in ridges and break. Steel rods can be set into the concrete when it is being laid. These help the slab to resist the forces of the weather.

A BUILDING FOUNDATION MUST REACH DOWN TO A SOLID LAYER OF THE EARTH'S CRUST.

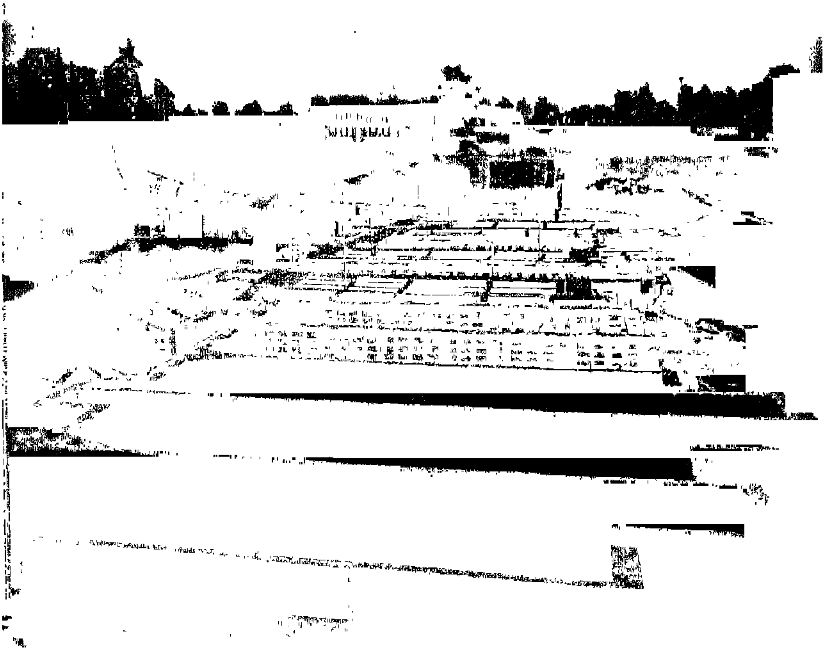
## 12. How are good house foundations made?

Just as with roads, our houses are only as good as their foundations. If a house is built on top of a loamy soil, one side may sink when the soil becomes wet. The freezing and thawing of the soil beneath may leave the different sides of the house at different levels and cause the walls to crack inside. The best foundation for a house would be one of concrete reinforced with steel rods. If the soil and subsoil were removed down to the rock, so that the foundation rested on the rock, it would be even more firm.

In many places it would be necessary to go down so deep to reach the rock that foundations cannot be set on rock itself. If there is hard clay beneath, a very good foundation for a home may be made on this material. The soil must be removed to a depth below that to which the ground freezes in winter. Usually a footing is made at the bottom of the trench. The footing is wider than the foundation wall in order to make a broader base. Often steel rods are bedded in the concrete of the footing.

*Examine the footing for a building foundation. How deep in the ground are footings placed for two-story houses in your neighborhood? How much deeper are the footings for apartment houses? Explain why it is necessary to go so deep.*

A GOOD HOUSE FOUNDATION CAN BE MADE IN CLAY SOIL.



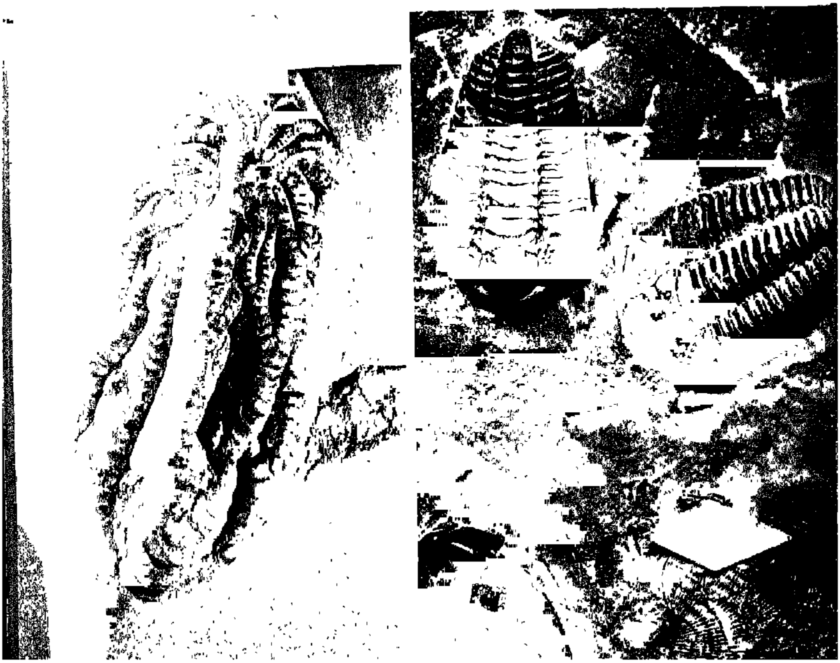
*What is the purpose of a footing? Why do the walls of buildings crack if improper footings are placed under them? Why are footings made deeper at some places than at others?*

If the ground about a house holds water, it is necessary to place drain tile around the footings to lead the water to some lower level. Many foundation walls are now waterproofed by applying a coating of some water-tight substance to the outside of the wall.

In sandy and soft ground, long piles or pillars are often put into the ground below the foundation walls of tall buildings to support the great weight that is to be carried by the foundation.

We have discussed in this chapter only a few of the things that can be learned about the crust of the earth. If you will keep your eyes open as you go about, you may be able to learn many more. If you will apply the few ideas given in

YOU SHOULD BE ABLE TO FIND FOSSILS LIKE THESE IN A LIMESTONE REGION.



this unit, you should be able to make your world a much more interesting and a much safer place in which to live.

### THINGS TO DO

1. It is about 8000 miles through the earth at the center. A very deep well might be 7000 feet deep. How much of a hole does such a deep well make in the earth? Draw a line all the way across the front blackboard of your classroom. Measure this line in inches. Suppose that this line represents 8000 miles. If you make another line to represent the depth of a 7000-foot well to the same scale, how long will this second line be?
2. Visit a bluff along a stream, a cut for a railroad or highway, or an excavation for a large building. How deep is the cut into the earth's surface? Can you find any evidence to indicate whether or not this cut has gone all the way down through the crust of the earth? List in your notebook all the different kinds of substances that you find contained in the earth at this cut. Bring some samples to the school laboratory with you. Try sifting some of these samples to find what different things may be in them. Can you find any remains of living things in the soil and rocks of the cut? Can you find any things in the soil that are alive now?
3. From bulletins on lawn building, describe how to build a soil for a good lawn in your community. Make a four-minute report on what you are able to find out.
4. Form a committee of the class to invite a city engineer or a highway engineer to talk to the science classes on road and street building.
5. Can you make sand? Explain. What materials are needed? What are the difficulties?
6. Can you make a rock? Explain. How would you prove your answers? Give a demonstration.

7. Can you make soil? Explain. Demonstrate. What are your raw materials?

### SOME THINGS TO REMEMBER

1. The earth is a sphere.
2. The earth is about 25,000 miles around at the equator.
3. Compared with the things which we can see, the earth is very large.
4. Modern inventions in travel and communication make the earth seem smaller to us.
5. Water covers a large part of the earth's surface. (About three fourths of the total surface.)
6. The atmosphere is a part of the earth's outer covering and turns with it.
7. The mountains and valleys of the earth's surface are small compared with its total size.
8. The interior of the earth is believed to be rigid and hard. We know very little about the interior of the earth.
9. Soil consists largely of broken-up rock.
10. The heat of the sun, the water of oceans and rivers, rain water, the ice of glaciers, freezing, and winds have broken the rocky crust of the earth into soil.
11. A part of the soil consists of decayed plant and animal materials.
12. The soil is the home of much of the life on earth.
13. Air and water on the earth's surface make life possible.
14. A good soil must be loose and open enough for water to circulate through it.
15. Removing the plant growth from a piece of land tends to make the soil on this land poorer from year to year.
16. A good soil must hold water, as well as let surplus water drain away.
17. The kind of subsoil under the upper soil layer has much to do with the reserve water supply for growing crops.

18. Water rises in the soil through the small pores between the solid particles.
19. Organic matter added to soil improves the condition of most soils for growing plants.
20. Good plant-growing soils often provide poor foundations for roads and buildings.

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# UNIT THREE

## UNIT THREE

# The Air We Breathe

### WHAT THIS UNIT IS ABOUT

We have said that we live on the crust of the earth. In reality there is a layer of air about the earth which is a very real part of it and turns about in space with it. The outer edge of the earth extends out into space some two hundred miles further than the rock crust upon which we walk. Instead of living on the surface of the earth's outer layer, we live immersed in it. Air is everywhere around us. It is quite true that we live at the bottom of an ocean of air. Air is so transparent and colorless that it is invisible. Our bodies are so constructed that we are not conscious of the weight of the air upon us. For these reasons we do not often think of the presence of air or of its importance in our daily lives.

Air is necessary for the existence of all kinds of plant and animal life. Of course people need air to live. You have often had the experience of panting or gasping for breath after running or taking some form of strenuous exercise. Wherever we go, or whatever we do, air is one of the urgent necessities of life.

Air is present everywhere under natural conditions. We are so accustomed to the presence of air in all of our everyday activities that we often fail to recognize its existence. We say that a glass, a jar, or a pitcher is empty when in reality each is filled with air. There are no empty containers under ordinary circumstances. Nearly all are full of air. An empty house is full of air. If it were empty, it would collapse from the air pressure on the outside.

We have learned to remove air from some kinds of containers. Where air is removed and a true vacant space left, we say that there is a *vacuum*. Some kinds of food are packed in a vacuum. Perhaps you have opened a can that was vacuum sealed and heard the air rush in to fill the empty space.

Air serves to carry most of the sounds that we hear. We depend upon the air to carry the sounds of our voices to relatives, friends, and neighbors. Music would not exist if the air were not present to carry the sound vibrations to our ears. For most ordinary purposes we should be deaf without the air. Can you imagine living in such a world?

We have said that the air extends upward to a great height above the crust of the earth. Air also penetrates into the spaces in the crust itself. Much plant growth depends upon the fact that air enters the spaces between the soil particles. Animal life in the earth depends upon air in the soil for an oxygen supply. Air is mixed with all natural waters in creeks, ponds, lakes and in the ocean. Aquatic creatures get oxygen from air mixed in water.

Many of our modern machines depend upon air for their operation. Most pumps work by means of air pressure. Our bicycles and automobiles ride upon cushions of air. Even such games as football, basketball, volley ball, and tennis are played with balls inflated with air. You may be interested to try to make a list of all of the things about your home that make use of the air.

In this unit we shall try to get some explanation of the ways in which we depend upon the air in our daily living.

# The Air We Breathe

## UNIT PROBLEMS

1. What substances are found in air?
2. Why do we breathe?
3. What is the most healthful air for us to breathe?
4. How do different kinds of animals get air?
5. Why do aviators find it hard to breathe at high altitudes?
6. How does air help us to hear?
7. How can we use air to do useful work?

### 1. What substances are found in air?

*When we take a glass or jar from the cupboard we usually say that it is empty. If you try to push an apparently empty glass tumbler down into a pan of water you will find that the glass does not fill with water. There is something in the glass that prevents the water from filling it. If you will run a small piece of rubber tubing up into the glass and draw the air out by sucking on the end of the tube, the water will rise into the glass to fill it. The same effect can be produced by tilting the glass so that the air has a chance to escape between the edge of the glass and the surface of the water as the glass is forced down into the water.*

Air is not just one simple substance but is a mixture of several substances. Most of the air consists of two colorless, odorless, and tasteless gases. These are *oxygen* and *nitrogen.*

You can demonstrate the approximate amount of the air that is made up of oxygen by this very simple experiment: *Place a lighted candle in the center of a bowl. Next partly fill the bowl with water. Cover the candle with a clean jar (a pint fruit jar will do). As the candle flame dies out, water will rise in the jar. If we measure the height of the water in the jar and compare it with the height of the jar, we shall find that about one fifth of the jar is filled with water. Why did the water enter the jar? Evidently there was room for it after the candle flame was extinguished. This is true because the flame used the oxygen from the air as the candle burned. When the oxygen in the jar was used, the water rose to take its place.*

Oxygen makes up one fifth, or twenty-one per cent, of the volume of the air. By volume we mean the space occupied by a thing. We can find out if a large amount of oxygen is present in a jar by lowering into it a splinter which has a glowing ember. If much of the gas is present, the stick will burst into flame. *Heat some red rust of mercury, mercuric oxide, in a test tube, and lower a lighted stick into it. As the oxygen is thrown off, the flame burns brightly.*

All living things depend upon the oxygen of the air. The oxygen in the air causes iron to rust, and materials made of copper and brass to become dull and tarnished. There is more oxygen in our world than any other chemical element.

*Prepare some oxygen for examination by heating potassium chlorate and manganese dioxide together in a test tube in a flame of a Bunsen burner. Collect the gas in wide-mouthed bottles. See diagram, page 248. Place an iron nail in one of the bottles, which is kept tightly closed. Examine the nail in a day or so. Explain the results. Lower a glowing splinter into another of the bottles. Examine a third bottle of oxygen carefully to learn if the gas has any taste or odor.*

Nearly four fifths, or seventy-seven per cent, of the air is

MANY BALLOONS ARE NOW FILLED WITH HELIUM, A NONINFLAMMABLE GAS.

nitrogen. Like oxygen it is a colorless, odorless, and tasteless gas. The jar in our second experiment was largely filled with oxygen and nitrogen. When the water rose in the jar after the oxygen was exhausted by the burning candle, the space above the water consisted for the most part of nitrogen. Nitrogen is unlike oxygen in that it does not combine with other substances in the process that we know as burning.

Nitrogen forms a part of the tissues of all living things. Plants do not grow well in soils that do not contain fairly large amounts of nitrogen compounds. Part of the foodstuffs of all animals must contain nitrogen compounds that we know as proteins. See page 238.

Outdoor air always contains small amounts of a gas called carbon dioxide. Only four one hundredths of one per cent (.04%) of the air consists of the colorless and odorless carbon dioxide. This gas enters the air as fires burn, and when living things breathe. It does not accumulate in large amounts in the air, because carbon dioxide is used by plants as they grow, and manufacture our food. Like nitrogen, carbon dioxide will reduce or put out a fire.

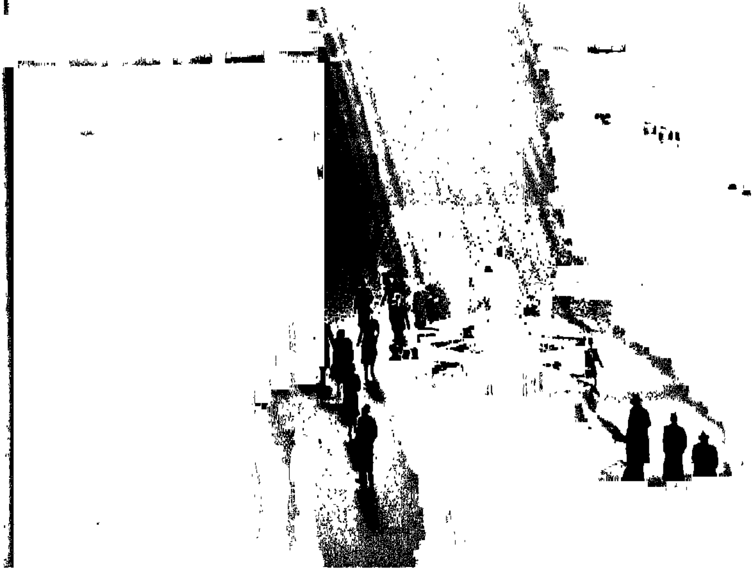
There is always some *water vapor* in the air. The air above a desert contains comparatively little water vapor, while that near the seacoast frequently holds so much that it forms a low-lying cloud called fog. Because the amount of water vapor in the air varies so much, we are unable to state the exact amount of it present in the air at any one time.

Other gases make up about one per cent of the air. *Helium, argon,* and *neon* are present in very small amounts.

Helium is now used to fill balloons and dirigibles that are lighter than air. It is used because it is not explosive. Neon is familiar to most of us as the gas which causes the red glow in the tubes of many of our most brilliant electric signs.

Small *solid particles* are suspended in the air. They are usually so small that they are invisible. Dust, soot, plant pollens, and bacteria are examples of solid impurities found in our atmosphere.

PARTICLES OF DUST CAN SOMETIMES BE SEEN FLOATING IN THE AIR IN A BEAM OF STRONG SUNLIGHT.



Dust particles in the air are not entirely a nuisance. Without them there might not be so many beautiful sunsets and sunrises. Most raindrops form when water vapor condenses around the solid particles in the air. When we are surrounded by large clouds of dust, the solid particles in the air become a nuisance. Even in small amounts some kinds of dust are extremely irritating.

Often when a bright beam of sunlight strikes across a dimly lighted room it is possible to see particles of dust in the air. *Try darkening a room and letting a beam of light in through a slit in a shade. You should be able to see dust particles in the air as the light strikes across it.*

### 2. Why do we breathe?

Air is one of the essentials for life. People can exist longer without food and water than they can without air. It has been estimated that every adult person needs almost fifty gallons of air each day. This large amount of air is secured during the process of breathing, which scientists call *respiration.*

How does the air enter our bodies? People obtain the air through the openings on each side of the nose called nostrils. Many dust particles, commonly present in the air, are strained or filtered from it by means of fine hairs in the nose. Air which enters the lungs through the mouth is much more likely to contain harmful dust particles than air which is secured in the proper way. In the winter, the air is cold, and may be unpleasant, even painful, when it enters the lungs of a mouth breather. If we breathe through our noses, the cold air passes over tiny "radiators," called turbinate bones, and is warmed before it goes far along the breathing or respiratory tract.

The air which is breathed in passes from the nose through the trachea, which is often called the windpipe. The *bron-*

*chial tubes* branch from the trachea and enter the right and left lungs where they branch into many small tubes.

The lungs are spongy organs. They are located in the chest or thoracic cavity. Muscles cause the chest to increase and decrease in size when we breathe. This permits the lungs to expand, to fill with air, and to partially collapse as the air goes out. When we inhale, or take a deep breath, the chest cavity becomes larger and the lungs also increase in size as they fill with air. When the used, stale air escapes from the lungs, they become smaller again.

In adults the process of breathing, or respiration, usually occurs from sixteen to eighteen times a minute. When we are taking some form of brisk exercise, the rate of breathing is increased. This is partly due to the fact that the body requires a greater amount of oxygen to enable it to carry on the added activity.

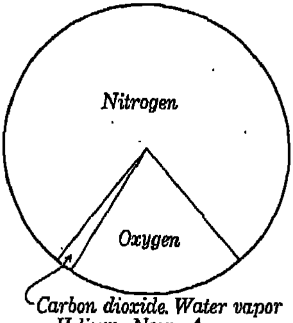
You have learned that the air is a mixture of gases. Materials which are in a mixture can be separated. The oxygen is taken from the air by the red corpuscles, in the blood, as the blood goes through the capillaries in the lungs. As the blood circulates, the red corpuscles carry the life-giving oxygen to all of the millions of cells in our bodies. Carbon dioxide, one of the waste products of the cells, is removed from them as the blood delivers the fresh oxygen.

In what ways is the fresh air different from the exhaled air which leaves our lungs? The fact that oxygen is necessary for life, suggests that air which leaves the lungs contains less of this gas than outdoor air. Carbon dioxide has been referred to as a waste product of the body. Exhaled air contains many times the amount of carbon dioxide present in fresh air. As a rule, the exhaled air contains more water vapor than outdoor air. Rare gases form approximately 1 per cent of inhaled and exhaled air. About the same amount of nitrogen is breathed into and out of the lungs. The following table gives the differences between outdoor and exhaled air.

| GASES IN AIR | APPROXIMATE COMPOSITION OF OUTDOOR AIR | APPROXIMATE COMPOSITION OF EXHALED AIR |
|---|---|---|
| Nitrogen | 77% | 77% |
| Oxygen | 21% | 16% |
| Carbon dioxide | .04% | 4% |
| Water vapor | Trace | 1.5% |
| Rare gases | 1% | 1% |

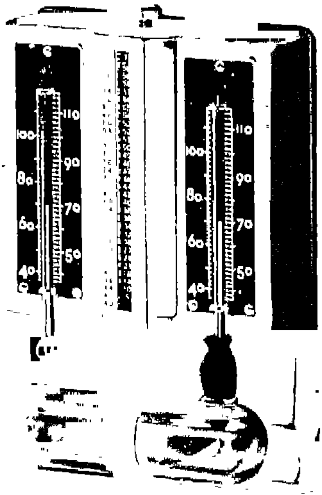
### 3. What is the most healthful air for us to breathe?

During what part of the year are there the most absences from school? A little thought will assure us that we miss many more days of school because of illness in the winter and early spring than in the late spring and early fall. During the warm weather people live out of doors much of the time. Windows of homes and schoolrooms are open, and they are surrounded by an abundance of fresh air. When the colder weather arrives, people frequently close their windows, and live in rooms which are filled with hot, and very dry, air.



THE APPROXIMATE AMOUNTS, BY VOLUME, OF THE DIFFERENT GASES WHICH MAKE UP THE MIXTURE WE CALL AIR ARE SHOWN ABOVE.

*Relative humidity*, usually referred to as humidity, is the comparison between the amount of water vapor actually present in the air, and the amount which would be present if the air were completely filled or saturated. If the air holds all of the water vapor that it can at a certain temperature, the relative humidity is 100 per cent. The per cent of relative humidity is learned by using an instrument called a hygrometer and consulting humidity tables, such as those which are used by the United States Weather Bureau.


THE HYGROMETER MEASURES RELATIVE HUMIDITY OF THE AIR.

The relative humidity has much to do with health and comfort. We may feel uncomfortably chilly when a room is heated to a temperature of 72° Fahrenheit (F.), or more, if the amount of water vapor present in the air is low. It is a familiar fact that wet clothes dry quickly when hung in warm, dry air. The warm, dry air of a room causes the moisture normally present on our skins to evaporate very quickly. As a result, we feel chilly, or even cold, in air of rather high temperature. Colds, and other diseases of the nose and throat, are the frequent results of living in air which is so dry that the moisture is removed from the linings of these organs.

In the summer we may feel very warm when the temperature is no higher than 70° F. A temperature of 100° F. in Chicago brings more suffering than a temperature of 130° F. in the Sahara, because the air in Chicago holds so much more water vapor than the air above a desert. Likewise, a temperature of 10° F. below zero in New York brings more discomfort than a cold wave of 20° below zero Fahrenheit in Montana, because the air in this northwestern state is less moist and humid than that in New York. Such a condition has occasioned the remark, "It isn't the heat, it's the humidity." In the winter, a room may feel too cool when the thermometer registers 68° F. if there is only a small amount of water vapor in the air. It is very evident that the relative humidity has much to do with our health and comfort.

Water vapor may be added to the air in a house by several methods. Some people place a small pan, or teakettle, of water on the top of a register or stove. A large bath towel may be wrung out of water and hung over a radiator or placed over a hot-air register. As it dries, the relative humidity will increase slightly. Growing plants kept well watered will give off some moisture to the air of the room in which they are kept. It is generally agreed that a relative humidity of from 40 per cent to 55 per cent and a temperature of 65° F. to 70° F. provide the most comfortable and healthful conditions for living rooms at home, or for most schoolrooms.

Many modern homes, hotels, and public buildings are equipped with air-conditioning machinery, so that the people who live or work in these places may be surrounded with air, free from dust, and of the most healthful temperature and humidity. In the summer, the air is cooled, and some of the moisture is removed. In the winter, the air is, of course, heated, and water vapor is added. In this way people are provided with the most healthful and the most comfortable living conditions.

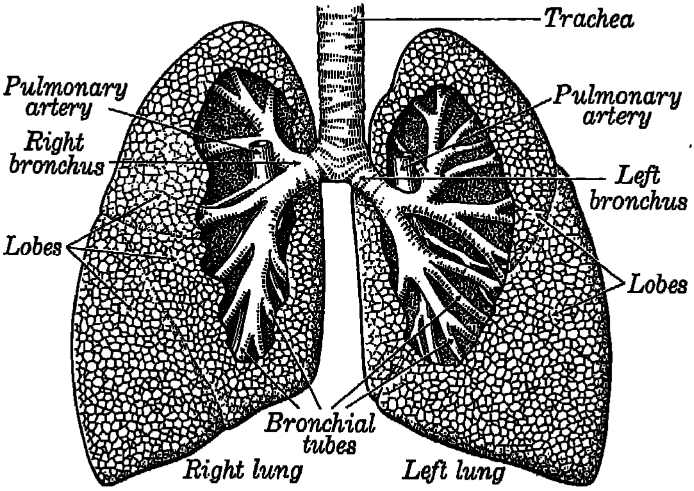
Travel on many of the transcontinental trains in summer has been made pleasant and comfortable, because they are air conditioned. People can now cross the deserts of our west and southwest in coaches kept at a uniform temperature and relative humidity.

The air in the country is usually more free from certain impurities than that in a city. When people are gathered together in large groups, there is a greater possibility of disease germs being carried through the air on the small "magic carpets" that we call dust particles. The smoke which escapes from the chimneys of factories and other buildings, as well as the carbon monoxide gas which escapes from the exhausts of countless automobiles, helps to make the air in our large cities less pure than that in some rural districts. Many people prefer to spend their vacations in the mountains or in the country because they prefer the air of those localities.

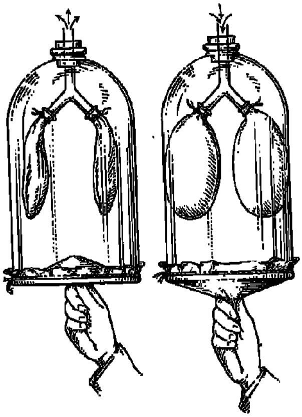
### 4. How do different kinds of animals get air?

Whether an animal lives in water or on land, it must have means of securing oxygen from the water or air surrounding it. It is an interesting study to try to observe how animals are adapted to obtain the oxygen used in respiration.

Some air, including oxygen, is always dissolved in natural



CAN YOU EXPLAIN HOW OXYGEN ENTERS THE LUNGS?



THIS DEMONSTRATION SHOWS HOW LUNGS EXPAND WHEN WE BREATHE. THE BALLOONS REPRESENT THE LUNGS; THE GLASS TUBE AN IMITATION TRACHEA; THE RUBBER SHEETING, THE DIAPHRAGM.

water. You have observed bubbles of air rising through water when it is first heated. Also, green plants growing in the water give off bubbles that are globules of oxygen.

*You can set up an experiment to show that green plants release oxygen as they grow. Place some elodea, or other water plant, in a beaker of water and cover it with a glass funnel. Invert a test tube filled with water over the stem of the funnel. Set the apparatus in a sunny window. When the test tube is filled with gas, test the gas with a glowing splinter for oxygen.*

The simplest animals, as the *amoeba* and *paramecium*, (see pages 138-139) absorb the oxygen through the surfaces of their one-celled bodies. The jellyfish and sea anemone also absorb oxygen through their entire body surfaces.

Some other aquatic (water) animals are provided with special organs of respiration called *gills*. Some gill-breathing animals, as the mud puppy and Necturus, spend part of their time out of the water, but when they are on land,

THE JELLYFISH AND SEA ANEMONE ABSORB THEIR OXYGEN FROM THE WATER.

EXTERNAL GILLS SUPPLY THE MUD PUPPY WITH OXYGEN OF THE AIR.

THE SLENDER SALAMANDERS ABSORB AIR THROUGH THEIR MOUTH LININGS.

the gills must remain moist or the animal will not live.

*Fish* are probably the most familiar animals among the gill breathers. The water containing dissolved oxygen enters the fish's mouth, passes over the gills, and out the gill slits. The gills contain a great many small blood vessels called capillaries. As the blood circulates through them, the oxygen enters the blood and is carried to the many cells in the fish's body.

Tadpoles, newts, crayfish, and their salt-water cousins, the lobsters, breathe by means of gills. Some aquatic insects have gill-like breathing organs.

Larger aquatic animals, as the whale, seal, and porpoise, breathe with lungs and must come to the surface when needing air. The "spouting" of the whale occurs when the animal exhales.

That important tiller of the soil, the earthworm, has neither lungs nor gills. Like some of the simple aquatic animals, earthworms absorb oxygen over the entire surfaces of their bodies. In order to do so, it is necessary that their bodies remain moist at all times. Because of this, earthworms are found in damp soil.

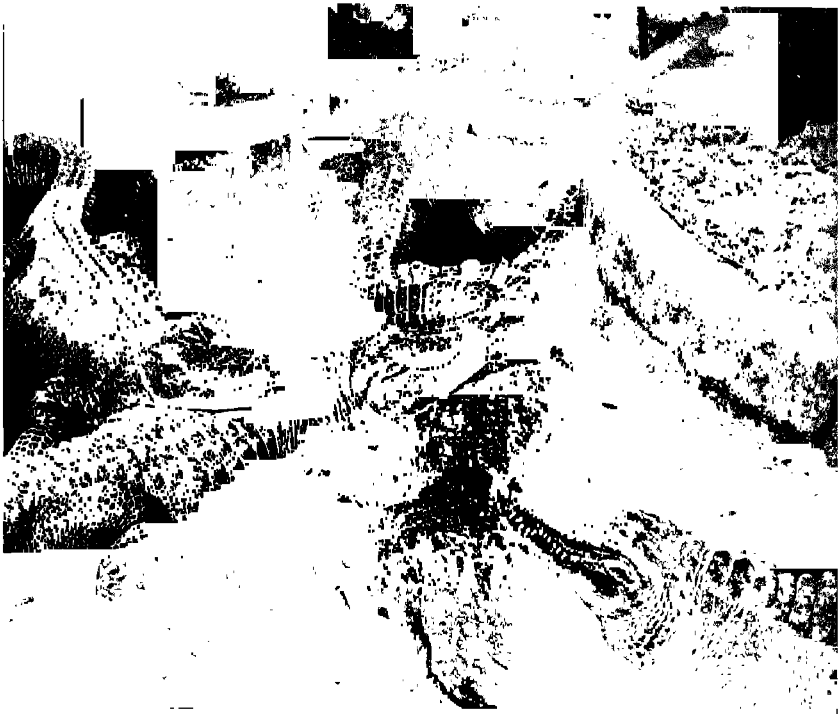
Sometimes people find little animals in the soil which resemble earthworms, yet have small legs and small eyes.

THE FROG, A LUNG-BREATHING ANIMAL, COMES TO THE SURFACE FOR AIR.

These little animals, called *slender salamanders,* belong to the same division of the animal kingdom as the frogs and toads. They are unlike their relatives, because they do not have lungs or gills but absorb air through the membrane which lines their mouths. The blood, which circulates through the capillaries in the skin and in the mouth membrane, takes the oxygen from the cells in the skin and membrane and distributes it to all of the cells in the salamander's body.

Other land animals, such as certain reptiles, birds, and mammals, obtain their oxygen through lungs.

*Reptiles,* including lizards, snakes, and alligators, are usually spoken of as being cold-blooded animals. They do not require as large amounts of oxygen as other animals and are usually sluggish and slow. Snakes usually have but one



ALLIGATORS ARE REPTILES THAT BREATHE WITH LUNGS.

lung, while lizards and alligators have two. The crocodile, often mistaken for an alligator, also has two lungs.

*Birds* have a higher body temperature than other forms of animal life. Because of this fact, they require larger amounts of oxygen, in proportion to their size, than other animals. Their lungs function most completely when they are in flight.

*Mammals* breathe with lungs. They are warm-blooded and include many groups. Man breathes with lungs. Our common pets, as white rats, dogs, and cats, are lung-breathing animals.

All *insects* are provided with breathing organs called *tracheae*. Small openings in the insect's body, which are called *spiracles*, provide a passageway for air from the outside to the tracheae. The tracheae are a system of tubes which distribute the air over the entire body of the insect.

The spiracles are easily seen in the grasshopper. The oxygen is absorbed by a body fluid, instead of blood, which carries the oxygen to all parts of the insect.

All animals, whether consisting of a single cell, or of many cells, must be constantly supplied with oxygen. The oxygen combines with the food that they eat and digest, in a process called oxidation. (See page 306.) The oxidation of foods gives animals both warmth and other energy.

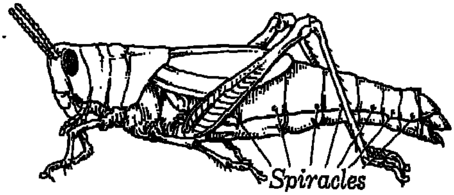
### 5. Why do aviators find it hard to breathe at high altitudes?

For lung-breathing creatures, especially humans, breathing becomes more difficult at high altitudes, that is, at great heights above sea level. This is well illustrated by our modern aviators who rise to great heights in airplanes.

The cockpit of an airplane contains various instruments to aid the aviator in the safe handling of his plane. One of the most useful of these instruments is the *altimeter*, a form of barometer which tells the pilot how high he is above sea level, and also what the air pressure is.

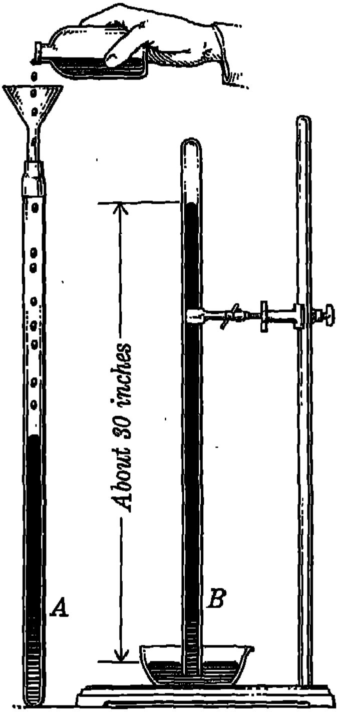
To understand how an altimeter works, we must first understand the purpose of a barometer. The first mercurial barometer was made by Torricelli, a pupil of the great Galileo.

It is difficult to perform Torricelli's experiment outside a good laboratory. It may, however, be done in the following way: *Obtain a piece of glass tubing about thirty-three inches long. Seal one end by heating it in the flame of the Bunsen burner. Fill the tube*



THIS SIDE VIEW OF A GRASSHOPPER SHOWS THE LOCATION OF THE SPIRACLES.

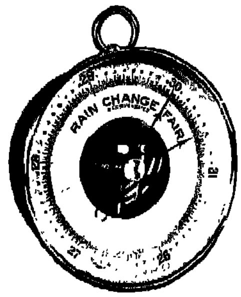
*with mercury, using a medicine dropper. When the tube is filled, invert it in a small dish which contains mercury, and support the apparatus by means of an iron stand. Some of the mercury will leave the upper part of the tube. The air in the room has just enough pressure to balance the mercury which remains in the tube. Carefully measure the height of the mercury column from the surface of the mercury in the dish.*



MAKING A MERCURIAL BAROMETER IS A SIMPLE PROCEDURE. WHY IS THE MERCURY COLUMN OF DIFFERENT HEIGHTS ON DIFFERENT DAYS?

If it were possible to carry the mercurial barometer to the top of a high building, as the Empire State Building in New York City, you would be able to see for yourself that the column of mercury was lower at the higher elevation.

Boys and girls who live in a mountainous district, such as that near Denver, will find that the mercury column in their barometers reaches a height of about twenty-five inches. New York City is almost at sea level, and there the mercury in a barometer will usually reach a height of about thirty inches. The height of the mercury column in a barometer varies with the altitude or the distance above sea level. Tables have been worked out which give the air pressure at different elevations. In general, the barometer reading is one inch less as the altitude increases one thousand feet. What would



AN AIRPLANE ALTIMETER IS AN ANEROID BAROMETER.

*the approximate* air pressure be when the airplane is at a height of three thousand feet? Of six thousand feet? Of ten thousand feet above sea level?

The mercurial barometer is so easily broken that it could not be used in an airplane. The *aneroid barometer,* or the altimeter, takes up little space, and there is no mercury to be spilled should the plane go into a nose dive. There is one further advantage. It is so constructed that readings may be made directly, although mercurial barometers can be made to read directly too. If you have a barometer in your home, it is probably of the aneroid type.

Why does the air pressure become less as the altitude is increased? On page 74 you read that we live at the bottom of an ocean of air. Scientists do not agree as to how far above the earth this atmosphere extends. Some think that it reaches fifty miles above the earth, and others that it may extend to a height of two hundred miles or more. When we are at sea level there is more air pressing on a barometer than at an elevation of five thousand feet. When an aviator reaches an elevation of 17,000 feet, the air pressure is only half as much as when he was at sea level. As higher altitudes are reached, the air thins out so rapidly that aviators would become unconscious if they did not carry a supply of oxygen in their planes.

**Discomfort at high altitudes.** There are three conditions which aviators find very uncomfortable when flying at high altitudes. The temperature lowers very rapidly as the earth is left behind. The specially constructed suits that fliers wear do not always protect them adequately against the cold.

The following table gives the temperatures which a naval aviator encountered when he took off from North Island, near San Diego, California, on the morning of August 7, 1935.

| ELEVATION | TEMPERATURE | ELEVATION | TEMPERATURE |
|---|---|---|---|
| Surface | 63° F. | 9000 feet | 58° F. |
| 1000 feet | 63° F. | 10,000 feet | 54° F. |
| 2000 feet | 73° F. | 11,000 feet | 50° F. |
| 3000 feet | 82° F. | 12,000 feet | 46° F. |
| 4000 feet | 80° F. | 13,000 feet | 42° F. |
| 5000 feet | 75° F. | 14,000 feet | 38° F. |
| 6000 feet | 71° F. | 15,000 feet | 33° F. |
| 7000 feet | 67° F. | 16,000 feet | 29° F. |
| 8000 feet | 62° F. | 17,000 feet | 26° F. |

The lessened air pressure also brings discomfort to aviators. Added to the intense cold, and lowered air pressure encountered at high altitudes, is the lessened supply of oxygen. This results in dizziness, and in some instances, unconsciousness, if a supply of oxygen is not carried in the plane.

### 6. How does air help us to hear?

Think of all the noises and sounds which surround us daily. The slamming of doors, the horns on cars, the hum of airplane motors, the voices of our friends, the songs of birds, the barking of dogs, and music of all kinds are known to us because we are surrounded by the atmosphere, or air. If the air were to disappear suddenly, we would find ourselves in a nearly silent world.

How is sound caused? If we strike a glass with a spoon or throw a rock into a pool of water, the surrounding air is set into rapid motion by the vibrations of the glass, or the water in the pool. Such vibrations cause disturbances in the air. These disturbances have been given the name sound waves.

These waves, which are carried through the air and strike the membranes of our ears, form the sounds that we hear.

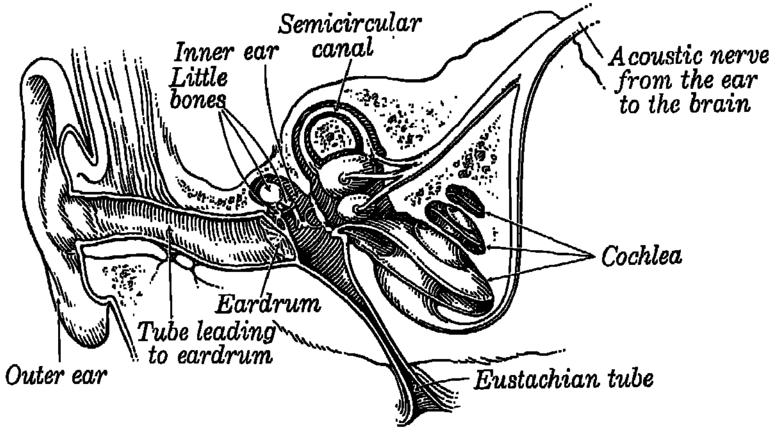
Other materials besides air carry sound waves. Water, the earth itself, wood, steel, and various metals are good conductors of sound. However, most sounds are carried from these substances to our ears through the air.

Boys and girls who live on either seacoast in the United States, sometimes hear the booming of the guns on battleships. If you are observant, you realize that you see smoke from the firing of the giant guns before you hear the report. Especially in cold weather, the "steam" from the locomotive is seen before the whistle of the approaching train is heard. During a summer thunderstorm, the thunder may be heard several seconds after the lightning has flashed across the sky. Do you think of other examples which prove that sound travels more slowly than light? As a matter of general interest to you, the speed of light is about 186,000 miles per second. Sound waves travel at a snail's pace compared with light waves. Air ordinarily conducts sound at a speed of 1100 feet per second. If sound came from a mile away, how long would it take it to reach our ears?

You will be able to demonstrate very easily the extent to which air conducts sound. *If your school has a vacuum pump and bell jar, suspend an electric doorbell connected to a dry cell in the jar. Be sure that the stopper in the top of the bell jar fits very tightly. Set the jar containing the bell over the plate of the air pump. When the bell is ringing, begin to pump the air out of the bell jar. Try to remove so much air that the sound of the bell will not be heard, although you see the vibrations of the clapper.*

As you know, the organ which makes it possible for you to hear the sounds carried to you in the air is the ear. You may be interested in briefly examining the structure of the ear.

**The Structure of the Ear.** The diagram shows three divisions of the ear; the outer, middle, and inner ear. The outer ear is shaped to catch the sound waves, and direct them against the eardrum which separates the outer ear from the middle ear. The sound waves cause the eardrum to vibrate, and the vibrations are carried through the three small bones in the middle ear to the inner ear. Branches of the auditory (hearing) nerve are in the inner ear. These nerves carry sensations of sound to the brain, and we are able to distinguish voices, the various musical instruments, and the many kinds of noises that are heard each day.



OUR EARS ARE VERY COMPLICATED ORGANS.

## 7. How can we use air to do useful work?

You have read that all living things need a constant supply of fresh air, and that there would be few sounds if there were no air. Air has had more to do with the development of our civilization than many people suppose. In earlier days, discovery and exploration were made possible because the winds, large waves of air in motion, furnished the power for sailing vessels. Many modern engineering feats would be impossible if air pressure were not used. Many machines and simple devices about our homes depend upon air pressure, which, as you know, is nearly fifteen pounds to the square inch at sea level. You remember air pressure decreases above sea level and increases below.

An experiment will show the power of air pressure: *Remove the shell from an egg which has been boiled for twenty minutes. Place the small end in a milk bottle in which a wisp of paper is burning. Explain why the egg is pushed into the bottle? Are you able to remove the egg from the bottle by increasing the pressure within the bottle?*

Another startling demonstration of the tremendous force of atmospheric pressure is the varnish-can experiment. *Get a gallon-size flat-sided varnish can with a small opening that can be easily corked. Be sure that the can has been thoroughly cleansed before you pour into it a half-pint of water. Set the can on a gas plate and boil the water until steam is seen coming from the opening in the can. Then quickly screw the cap in place or push in a tight stopper. Now plunge the can into cold water, or hold it in running water under the cold water faucet. Remove the can from the water. The can will collapse.*

The steam from the boiling water pushes the air from the can. Holding the stoppered can in cold water condenses the steam to water, leaving a partial vacuum in the can. When this happens the pressure inside is much less than the atmospheric pressure on the outside.

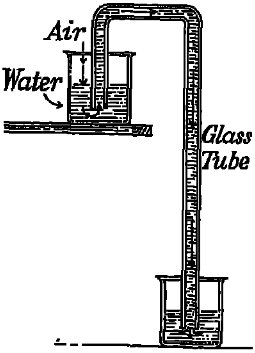
A common device that makes use of the force of atmospheric pressure is the siphon. Probably you have seen a rubber hose in the form of a siphon used to empty washtubs of water.

*To operate a siphon set two jars or buckets of water at different levels. Fill a piece of rubber tubing with water. Hold the ends of the tubing closed and immerse one end in the* *water of the jar at the higher level. Allow the other end of the tube to hang freely in the lower jar.* Water will run from the jar at the higher level up over the edge and into the lower jar. The water actually flows uphill for a distance.

The explanation of the siphon is clearer if you will examine the diagram on this page. The height of each of the two arms of the siphon is measured from the top of the bend in the tube to the water level in each jar. The small difference in water level makes the difference in the air pressure on the surface of the water in the two jars negligible. But, the weight of water in the long arm of the siphon is greater than the weight of water in the short arm. The water, therefore, flows in the direction of the long arm, provided the tube is filled with water in the beginning.

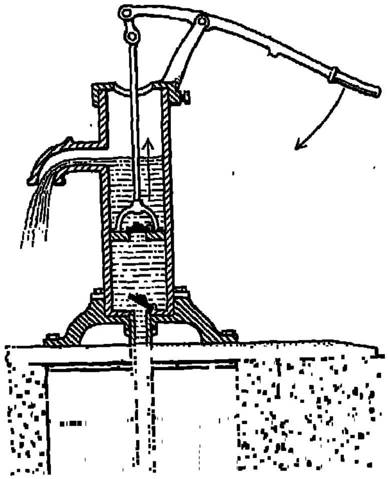
The familiar medicine dropper depends upon a partial vacuum inside the tube and the pressure of the air on the surface of the liquid into which it is dipped. Some of the air in the medicine dropper is forced out when you squeeze the rubber bulb. When the pressure on the bulb is released, the air pressure on the surface of the liquid in the bottle forces some of the liquid into the medicine dropper. Many self-filling fountain pens work on the same principle as the medicine dropper.

Vacuum cleaners, too, depend upon air pressure. An electric motor drives a small fan, which withdraws some of the air from the inside of the cleaner. Due to greater pressure outside, air rushes in to replace that drawn from the inside by the fan. This air carries dust and other loose materials, such as string and scuffed-off rug nap, into



A SIPHON MAKES USE OF THE FORCE OF ATMOSPHERIC PRESSURE.

the cleaner with it. *Examine a household vacuum cleaner.*



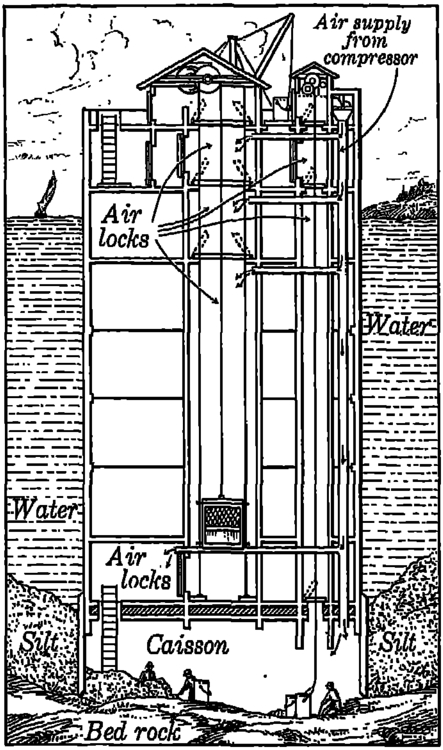
AIR PRESSURE ON THE SURFACE OF THE WATER IN THE WELL PUSHES THE WATER INTO THE CYLINDER OF THE PUMP.

The operation of most common pumps depends upon the pressure of the air upon the surface of the water. You can readily see how an ordinary lift pump operates by referring to the diagram on this page. On the first stroke that pulls the piston up in the cylinder, some of the air is removed from the cylinder. This lowers the pressure in the cylinder and allows the valve at the bottom of it to open. At the same time the pressure of the air on the surface of the water in the well pushes water up the pipe and into the cylinder. On the down stroke the valve at the bottom of the cylinder is forced shut. At the same time, pushing the piston down forces the valve in the piston open and allows water to be pushed up above the piston. On the next upstroke the weight of the water above the piston forces this second valve shut and the water is lifted up to the level of the spout where it runs out.

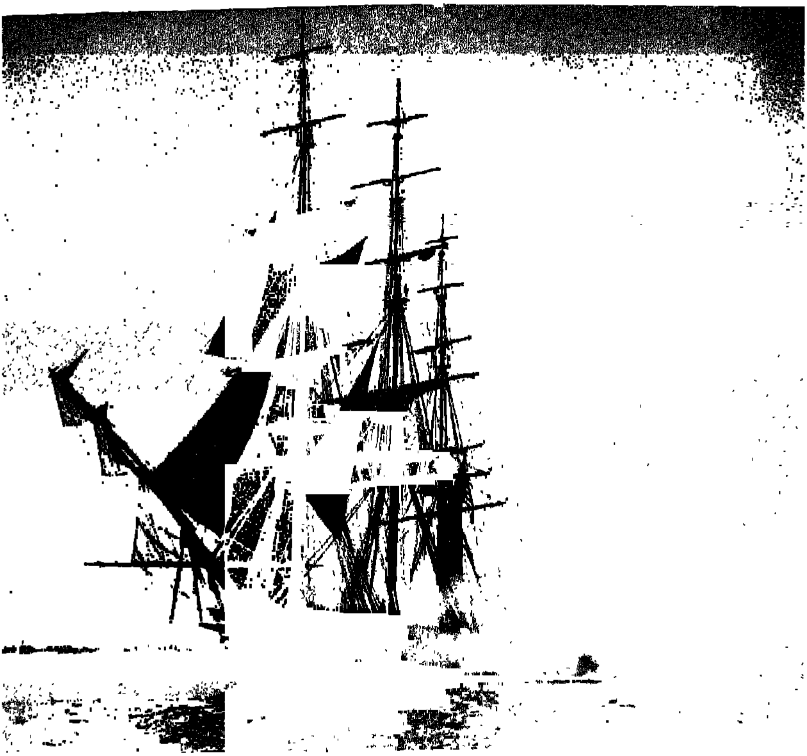
Air may be compressed; that is, much of it may be crowded into a relatively small space. Compressed air has many uses. It inflates the tires on automobiles and bicycles. It is used in a sandblast, driving sand against stone buildings to remove paint or grime. It furnishes the energy in the pneumatic drill used in cutting through concrete pavements. Frequently compressed air is used by a stonecutter to cut designs in marble and granite. It drives the pneumatic hammer and riveting tool. Compressed air sometimes furnishes the power which is needed to throw poison spray on fruit trees.

One of the most interesting ways in which compressed air is used is in *caissons*. The tunnels under the Hudson River were built by using these devices. Men worked in a steel-walled cylinder, while compressed air kept the water from entering the caisson. This great pressure puts a terrific strain on the human body, so that men can work in a caisson only a few hours each day. The foundations for many of the world's largest bridges have been made by men working in caissons.

In addition to devices that work by means of air pressure we use the force of the wind to do some of our work. Sailing ships have been known from very early times. Columbus made his journey from Spain to the New World with three small sailing ships. Today many people have small boats that are used for pleasure. A few ships are equipped both with engines and with sails. The cloth sails can be adjusted to the masts and spars so that the wind is caught in them and the boat moved before the wind. On calm days little progress is made. Sometimes the wind blows in a wrong direction,



MANY ENGINEERING PROJECTS REQUIRE THE USE OF A CAISSON. AIR PRESSURE KEEPS THE WATER FROM ENTERING THE STEEL WALLS OF THE CAISSON.



SAILING VESSELS ARE DRIVEN FORWARD BY AIR IN MOTION THAT WE KNOW AS WIND. THE "U.S.S. CONSTITUTION" WAS ONE OF THE MOST FAMOUS SHIPS OF THE AMERICAN NAVY.

and at other times it is so violent that sails must be reefed.

The windmill is another familiar device for using the force of the wind to an advantage. Windmills have been used for pumping water and grinding grain. Recently small windmills have supplied the power to generate electricity for farm homes.

### THINGS TO DO

1. Prepare some carbon dioxide. See exercise 4, page 248. Carbon dioxide will turn lime water milky. Fill a test tube with lime water. Blow into it through a clean glass tube or straw. What do you conclude?

2. Appoint a committee to secure information about the air conditioning of homes and public buildings.
3. Prepare a special report on helium.
4. Prepare a special report on some of the uses of nitrogen.
5. Learn how to make model airplanes, and fly them. Ask your woodshop teacher for suggestions, or consult some book in the school library for plans.
6. Ask your woodshop teacher for plans for making a sail boat. When your boat is finished, sail it on a pond, or small body of water near your home.
7. The class will enjoy making a science scrapbook on the subject of Air Transportation.
8. Get a copy of C. J. Lynde's *Experiments with Home Equipment*. Try two of the air-pressure experiments suggested in this book. Can you demonstrate and explain these for the class?

### SOME THINGS TO REMEMBER

1. Air is present everywhere.
2. The air is a mixture of gases.
3. Oxygen in the air helps to keep all living things alive.
4. Oxygen is necessary for combustion or burning.
5. The air is nearly four-fifths nitrogen.
6. Animals add carbon dioxide to the air as they breathe.
7. The higher we go, the less air there is above us.
8. The barometer is used to measure pressure of the air.
9. The temperature is much lower at high altitudes than near the surface of the earth.
10. Breathing is difficult at high elevations because there is less oxygen in the thinner air.
11. We obtain the oxygen that our bodies need during the process of breathing or respiration.
12. The red corpuscles in our blood carry oxygen to the millions of living cells in our bodies.

13. A relative humidity of about 54% is most healthful and comfortable.
14. The correct temperature for living rooms is about 68° F.
15. Many simple aquatic animals absorb air over their entire body surfaces.
16. Fishes and some other aquatic animals obtain needed oxygen through their gills.
17. Most of the insects secure air through small spiracles.
18. Larger land animals, as well as the mammals of the sea, breathe through lungs.
19. There would be practically no sound if there were no air.
20. Sound waves travel through the air at a speed of about 1100 feet per second.
21. Air pressure is used in doing useful work.
22. The air pressure at sea level is nearly fifteen pounds to the square inch.
23. Siphons, medicine droppers, and vacuum cleaners are some devices that depend upon air pressure.
24. Air may be compressed, and used in many ways.

### BOOKS TO READ

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Cobb, Walter F. *Health for Body and Mind.* Chapters 13 and 14. D. Appleton-Century Company.

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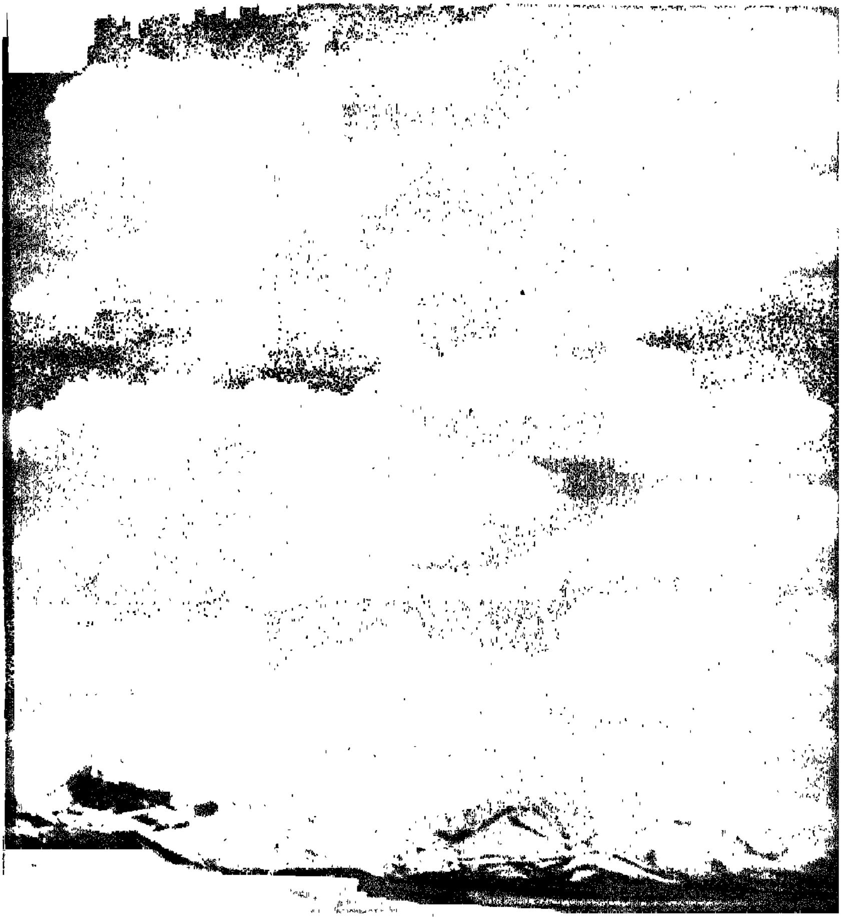


# UNIT FOUR

## UNIT FOUR

# Water and Life

### WHAT THIS UNIT IS ABOUT

Benjamin Franklin once said: "When the well's dry, they know the worth of water." Water is usually so plentiful that we often fail to realize how important it is in our own lives, and in those of plants and animals as well. Man, animals, and plants could not live without water, and the soil could not produce food, or materials for clothing and shelter.

People who have experienced long periods of drought know the hardships and suffering that result from a scarcity of water. Human beings can do without food for a much longer time than they can without water. When people who cross the deserts of our southwestern states in automobiles must sometimes pay for a drink of water as they pay for a glass of lemonade or ginger ale in other places, they realize the blessing of an adequate water supply.

Food, another requirement for human and animal life, becomes scarce in regions of drought. Many of you have seen plants wither and die because the necessary moisture was not available. Farmers know that rainfall is necessary during certain stages of the growth of different kinds of crops. If the rains are late, or altogether wanting, the crop-yield will be reduced and in some cases be a total loss.

When pastures fail, animals as well as people suffer from a lessened food supply.

Water exists in each of the three states of matter that are known to us as a gas, a liquid, and a solid. It can be changed from any one of its forms into either of the others.

We are most familiar with water as a liquid. Indeed, the largest part of our own bodies consists of water. As a liquid, water is of greatest service to all living things because so many other substances can be dissolved in it. Our own foods can be used by body tissues only when dissolved in water. Plants can get needed minerals only as these are dissolved in water.

As a gas distributed through the atmosphere, water can be carried by winds almost anywhere over the surface of the earth. If water could not be changed into vapor and back into a liquid, we should have no rains. You can readily see that it is most important for us as living creatures to have water changed into its gaseous form.

Solid water, ice, is widely used for cooling other substances. In any of its forms water is most essential to our living. The fact that one of the forms can be converted into the others makes the use of water much more easily controlled.

# Water and Life

## UNIT PROBLEMS

1. How do clouds bring rain?
2. How do we use water?
3. Why do human beings require water?
4. How is water used in our homes?
5. What foods contain water?
6. How do desert plants and animals get water?
7. When does water destroy living things?

### 1. How do clouds bring rain?

Why does a pond or small river often become a mere mud puddle by midsummer? What becomes of the water in wet clothes as they dry? What happens to the water that falls on the streets and sidewalks during a rain? *It will help us to answer these questions if we place a pan containing a cupful of water on a hot stove. We shall see a cloud of moisture form above the pan, and in a short time the water will have disappeared.* We say that the water has *evaporated.* It has gone into the air in the form of water vapor. Water vapor is constantly passing into the air as water evaporates from ocean, lakes, rivers, fields, and the weekly wash when it is hung up to dry.

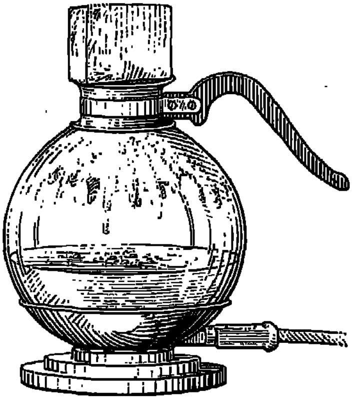
*Place an equal amount of water in two beakers or cups of the same size. Place one in a cool dark place; the other in a sunny warm place. Compare the water levels in the two beakers after leaving them over the week end. Write a statement about the effect of temperature on the rate of evaporation.*

Plants add large quantities of water vapor to the air. Much more water is absorbed by the roots of plants than remains in the plants. Most of the water that is absorbed passes out through tiny openings in the leaves as gaseous water. It then becomes a part of the water vapor in the air, most of which rises and falls later as rain, snow, hail or sleet.

Forests supply a large amount of water vapor to the air. Is this a good reason to plant trees to replace those cut down for commercial purposes?

The water vapor in the air forms droplets which gather into clouds that we see at different seasons of the year. In the summer, thunderstorms may develop very suddenly, and the cloud above us may be the source of a heavy shower. In the winter, clouds filled with moisture may travel across the United States, causing rains on the Pacific coast, and rains and heavy snows on the states to the eastward.

Sometimes a cloud laden with water droplets comes so close to the surface of the earth that it envelopes the surrounding countryside. If very minute droplets are suspended in the cloud, then we say there is a mist. Fogs contain larger droplets or more moisture than mists. Fogs may be of such denseness as to hinder travel either at sea or on land, and in some cases a fog may be too thick to see even a few feet away. Anyone who has seen pictures of one of the famous London fogs can realize how dense these surface clouds can be. A remarkable fog occurred in London on January 28, 1909. On this occasion the city was under a thick fog all day.



HAVE YOU EVER SEEN A CLOUD FORM IN A COFFEE-MAKER?

The thickness of fogs is dependent, of course, upon the amount of moisture or water droplets that have been gathered into the cloud. One of the chief contributing factors to formation of fogs on the British Isles is the many bodies of water surrounding these islands. How does this affect the amount of water vapor taken up by the air?

Rain or snow does not always occur when clouds are seen above us. Some clouds, such as those shown on page 103, are associated with fair weather. However, if one of these *cumulus* clouds should be suddenly cooled by currents of cold air rising near it, rain or, in some instances, snow might fall from it. *Nimbus clouds* are the sources of the heavy rains and snows which add the very necessary moisture to the surface of the land.

You can carry out a simple experiment which will make it possible for you to see a small cloud form. *Get a clear glass coffee-maker that will hold about one quart of water. Use only the lower part of the coffee-maker. Run about an inch of water into the bottom of this. Heat the water until it begins to boil. Remove the coffee-maker from the heat. Place a piece of ice too large to go inside in the open mouth of the glass vessel. An ordinary refrigerator ice cube will serve. As the cool air passing over the ice cube drops inside and the warm vapor rises from the surface of the water, the water vapor will condense and a small cloud will form inside the coffee-maker. See diagram, page 107.*

Water evaporates from the earth's surface because of the sun's radiant energy. When energy from the sun strikes the rocks, soil, and water on the earth's surface some of it is absorbed as heat. The air that touches the warmed surface of the earth becomes heated itself and carries this heat to the near-by air. This helps to warm the whole atmosphere. You will observe that evaporation is most rapid when the temperature of the air is high. If evaporation should cease, our earth would become a huge desolate waste. Why is this so?

The water vapor is mixed through the air much as a lump of sugar dissolves in a glass of water. We can prove that there is water vapor in the air of the room. *Fill a glass bottle with ice water, and fit a cork into the bottle. Wipe the bottle until there is no trace of moisture on it. Then place it on a dry plate on a table in the room. In a few minutes drops of water will appear on the bottle. In a half-hour or so the plate will also be wet.* This moisture can come only from one source, the water vapor of the air. When the warm air strikes the cold bottle, the water vapor in it condenses into liquid water. Out-of-doors, if the upper air cools sufficiently, some of the water vapor forms into clouds having a variety of shapes. Clouds form where saturation is reached and water droplets, or snow and ice crystals, form. Further cooling increases the size of the droplets, or crystals, by addition of more water until their weight brings them down as rain or snow.

### 2. How do we use water?

Water exists in each of the three states of matter known to us—solid, liquid, and gas. *Solids* can be grasped and handled. They can be made into any desired shape and remain in this shape. Wood and stone are common examples of solids. *Liquids* when left to themselves have no definite shape. Water, the most common liquid, takes on the shape of the container that holds it. A pond is round or rectangular because the water is held in a round or rectangular depression in the earth's surface. *Gases* do not keep fixed forms as solids do. Most of them are invisible. Gases do not have a constant *volume* like liquids, but their volume, or the space which they occupy, varies with slight changes of temperature. We are most familiar with water as a liquid, and least familiar with it as a gas. People who live in the tropics know little of water as ice, while the Eskimos are acquainted with water in all three of its forms. Dwellers in the temperate zone have learned how to make and use ice and how to make use of steam in a variety of ways.

When in its liquid form, water is one of the most common of the materials necessary for everyday living. As you know three fourths of the earth's surface is covered with water, and it seems that water should be plentiful everywhere. We shall learn later that this is not always so. Each one of us uses many gallons of water a day. *Before reading the next part of this unit, make a list of the many ways in which water is used in your home and community.*

People who live in parts of the United States where winter weather brings freezing temperatures know the joys of ice skating. Years ago skating was frequently interrupted when river and pond ice was cut and stored for use in refrigerators during the following summer. People have known for a long time that foods placed in a refrigerator will keep for a much longer time without spoiling than foods kept at ordinary room temperatures.

One of the earliest scientific experiments was performed by an English scientist, Sir Francis Bacon. This scientist ordered his carriage stopped one cold winter's day so that he might get out to bury a chicken in the snow. He wanted to see for himself if the low temperature would prevent the decay or the spoiling of the fowl. As a result of his scientific curiosity, Bacon developed a severe cold, which caused his death. Today, artificial ice and electrical refrigeration have begun to replace the germ-laden river and pond ice of thirty or more years ago.

Have you ever wondered why ice floats in water? You can answer this question for yourself, if you will perform one of the following experiments: *If you are studying this unit during the cold winter months, fill a can with water to a depth of ten inches. Place the can outdoors. When the water has frozen, shake out the block of ice and measure its depth. You will find that it has filled the can to a depth of almost eleven inches. Do not use a can that is valuable as the freezing of the ice may break or bulge it. If you are studying this unit during warm weather, some one pupil who has an electric refrigerator in his home may perform an experiment and report the results to the class. Fill a small pan with water, and place it in the freezing unit of the refrigerator. After the water freezes, measure the thickness of the ice and compare it with the depth of the water that was in the pan. How does the volume of the water change as it becomes ice? Which weighs more, a pan*

AN ICEBERG IS SOLID WATER. WHY DOES AN ICEBERG FLOAT?

*filled with water or the same pan filled with a solid block of ice? Can you now explain why ice floats?*

When water is heated to its boiling temperature, 212° F., it changes into a gaseous form called *steam.* It is not steam that we see, however, because steam is an invisible gas like the air which surrounds us. If the steam does not escape as the water boils, it develops considerable pressure. The power in it can be shown by a very simple experiment. *Fill a hard glass test tube half-full of water, and fit a cork into the mouth of the test tube. Using a test-tube holder, hold the test tube in the flame of a Bunsen burner. In a few minutes the cork will be blown from the tube. Do not point the tube toward anyone or get your face close to it. Repeat the experiment to make sure that you can see no steam in the tube.* When steam escapes from a teakettle, it condenses into a small cloud. The cloud is composed of tiny particles of water. If some cold object, as a spoon, is held in this water vapor, drops of liquid water form on the spoon. When water vapor strikes a colder object, it condenses, and we see it as small drops of water.

You know that ice is generally used to prevent the spoiling or decay of foods. Steam is also used to preserve our foods. Using steam is one of the best ways of killing microbes, and making materials *sterile.* Hospitals have large steam sterilizers in which the surgeons' instruments are made germ free. Perhaps you have seen steam used in a restaurant or hotel kitchen to sterilize the dishes and silverware. Dairies also use steam to kill germs that may be in the various parts of the machinery for pasteurizing milk.

We are usually drawn by a steam locomotive when we travel on a railroad train. The boilers of the locomotives hold large quantities of water which are changed into steam when the water is heated.

Perhaps your home or schoolroom is heated and lighted through a use of steam. In the steam-heating systems water in the cellar boiler is heated to boiling point and the steam thus formed travels by means of pipes to radiators in the various rooms. Steam heat is the most satisfactory means of heating large buildings. See pages 321-322.

Sometimes cities generate electricity by means of a steam turbine. This supplies a rotary motion which in turn is used to generate the electricity. Steam issuing from jets is made to strike small cups on the edge of a wheel. The energy of the steam makes the wheel turn and thus supplies power. Plants and manufacturing concerns frequently make use of steam turbines to supply the power for generating electricity.

Some railroads are now being run by electricity generated at large power plants. Steam turbines may be used to generate this electricity.

Falling water is also used to supply the energy to generate electricity.

Rain is nearly pure water when it falls from the clouds. If this liquid is frozen, it becomes ice, the solid form of water. When this ice melts, and the water is boiled, the steam can be condensed into water that has the same composition it had when it fell as rain. Water, ice, and steam have the same chemical formula. The chemist writes it $H_2O$. (See pages 227-228.) This is simply a short way of showing that water consists of two parts hydrogen and one part oxygen.

### 3. Why do human beings require water?

You know air is required for the continued life of mankind. Water is also a requirement for life. When you are told that about two thirds of your own body weight is water, you can understand that water is necessary for your growth and gains in weight and height.

The water that we drink serves a variety of purposes in our bodies. The different parts of the human body that require water for definite reasons are discussed in Unit Eleven. Here we shall mention very briefly some of the ways in which water is a necessary requirement of every human being.

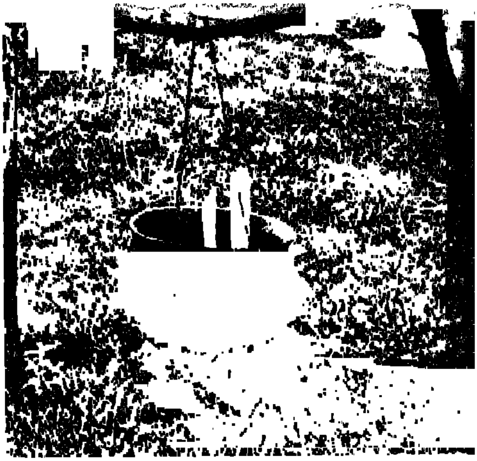
The blood furnishes the means of transportation for foods, oxygen, and waste products to and from the various parts of the body. There are usually from five to six quarts of blood in every healthy adult. This blood is largely water.

Many people do not drink sufficient amounts of water. Older boys and girls, as well as adults, should drink five or six glasses of pure water every day. Some of this water is used in the processes of the digestion of our food, so that the food we eat may be made useful for our bodies. Much of it does not remain in the body, but is eliminated through the organs of excretion, particularly the kidneys and skin.

The skin excretes perspiration, which is mainly water in which certain waste materials are dissolved. Perspiration occurs to some extent when we are sitting quietly in a room of a comfortable temperature and humidity. When we become overheated, or when we are exercising vigorously, perspiration pours from the thousands of sweat glands in our skins. We may gain some idea of the amount of water that the body may lose through perspiration from the weights of football players before and after a game. A boy who weighs one hundred and eighty pounds before a game may weigh only one hundred and seventy-five pounds at its close. The difference in weight is due to excessive perspiration. This same boy will quickly regain his lost weight through the water he drinks, and the food that he eats.

The evaporation of moisture lowers the temperature of the body and tends to keep it at an even temperature. Cooling a hot pavement by sprinkling it illustrates this principle.

Water is necessary for the removal of perspiration and dust and dirt from the skin. For cleansing purposes, warm



SOAP USED TO BE MADE AT HOME IN SOAP KETTLES.

water and soap are necessary. Water is a *solvent,* that is, it dissolves many kinds of substances. *Arrange six test tubes half filled with water in a test-tube rack. Add a small amount of the following substances to the different tubes: baking soda, sugar, fine sand, common salt, alcohol, and olive oil. Make a list of materials and place an "S" before those that are soluble in water.* Fats and oils, however, do not dissolve in water. In order to remove the somewhat oily perspiration from the skin, soap is needed in addition to warm water.

An experiment will explain why warm water alone will not remove oily substances, such as perspiration. *Add two or three drops of olive oil to a test tube half filled with warm water. What happens? Now add ten drops of liquid soap to the tube and shake thoroughly. The oil and soap formed an emulsion, so that the oil no longer floats on the surface of the water. In the same way, soap forms an emulsion with the oily perspiration, so that it can be removed from the skin.*

A daily bath with warm water and soap will keep the skin in excellent condition. When a daily bath is impossible, two such baths a week should be considered a necessity in order to keep the skin in a heathful and inoffensive condition.

Water is needed on the outside as well as on the inside of the human body. People with high standards of cleanliness use many gallons of water each day.

### 4. How is water used in our homes?

People who live in homes where the water is piped into the houses do not realize how many gallons are used each day. If the water is pumped, and then carried into the house, less is used. However, several bucketfuls are needed each day, and on certain occasions large quantities are used.

The uses of water in the home center largely around the idea of cleanliness. Water and soap can transform an unsanitary house into a home that is sanitary and livable. The water that is used in keeping the home clean and sanitary, for dish washing, and for laundry and bathroom purposes, must be disposed of. In modern homes this water, along with solid wastes, is run into sewers or septic tanks.

A home seems more complete with a lawn, shrubbery, and flowers. Cities have learned that they are much more attractive and homelike when they have parks here and there. Many families grow a part, if not all, of the vegetables which are used in the home. Ordinarily little irrigation is required in the eastern states. However, if rains do not come at the right time, or if seasons of drought prevail, the lawn and other plants must receive artificial watering, or irrigation. In the arid (dry) sections of the western states, home owners need to irrigate lawns and gardens during much of the year.

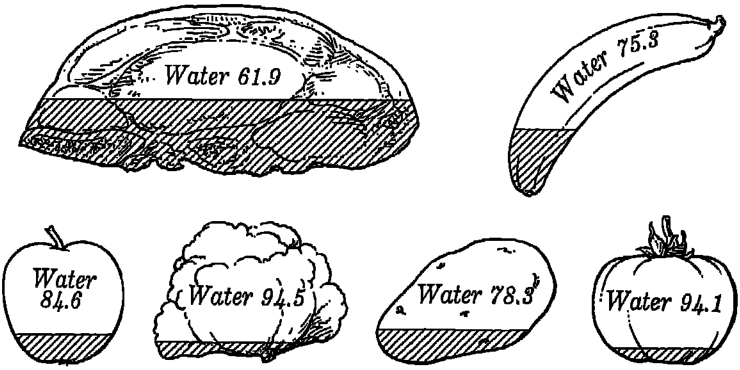
Irrigation of home grounds and of city parks is frequently accomplished by spraying or sprinkling the water on the soil. Sometimes furrows or trenches are dug between the rows of vegetables and flowers, and around trees and shrubbery. Water is then run into the trenches, and seeps into the soil where it can be absorbed by the plants' roots. In towns where the water is metered, the amount used for irrigation purposes can be estimated by comparing the sizes of the water bills during the season of rainfall and times of drought.

You can easily observe how irrigation works in the school classroom. *Build a shallow wooden tray that will hold water, or find a large shallow metal pan. Set this in a sunny window.*

*Set in the tray pots of flowers that can be brought from home. Be sure that the pots have holes in the bottom. Water the plants by pouring water into the tray around the bottoms of the pots. Do not pour more water in the tray than the plants will take up within a relatively short time. Do not let the plants stand in water for any length of time. See if you can keep the plants in good growing condition for six weeks by this method of irrigation.*

### 5. What foods contain water?

Milk is referred to as being the most nearly complete or perfect food. When the chemist examines milk, he finds that it contains a variety of food materials. Milk contains sugar; proteins that build and repair tissue; calcium and phosphorus needed for strong bones and teeth; fat, which we call cream; and Vitamins A, B, and G. While milk contains a variety of solid materials these form only about thirteen per cent of the total weight of the liquid. Water is by far the most plentiful substance in milk. It makes up approximately eighty-seven per cent of its weight.



ALL VEGETABLES, FRUITS, AND ANIMAL FOODS CONTAIN WATER.

Let us consider other foods which are not liquids, but solids. We commonly think of meats as being among the most nourishing and strengthening of foods. It is rather surprising to discover how much of a pound of beefsteak, for example, is water. Chemists tell us that about sixty per cent of beefsteak is water. Other meats contain large amounts of water. Chicken is seventy-two per cent, and pork steak fifty per cent water.

We should expect fresh fruits and vegetables to contain large amounts of water. Chemical analysis proves this to be true. Apples are eighty-three per cent water; bananas, seventy-five per cent; cabbage, ninety-one per cent; celery, ninety-four per cent; lettuce, ninety-four per cent; oranges, eighty-seven per cent; potatoes, seventy-nine per cent; and tomatoes, ninety-five per cent water.

Dried or dehydrated fruits and vegetables are often used. When foods are shipped long distances it is expensive to transport them when they contain large quantities of water. When Admiral Byrd ordered the supplies that were taken on his last expedition to the Antarctic, tons of potatoes, carrots, and other vegetables were dehydrated (dried). The dried vegetables occupied much less space on the ship and kept in good condition much longer than vegetables containing much moisture.

*Peel some apples or potatoes, and cut them into thin slices. Weigh out a pound of the material and place it in an uncovered pan in an oven, having a temperature of 250° F. Watch the material, taking care that it does not burn. Weigh the substance after it has been in the oven for one hour. Figure the percentage of water that has evaporated from the food.*

You know that dried peaches, prunes, raisins, and such foods as navy beans, cornmeal, macaroni, and flour can be

ONLY DESERT SHRUBS CAN GROW IN THE SOIL OF CERTAIN SECTIONS OF THE SOUTHWEST. WHAT IS NEEDED TO TURN THIS INTO A FERTILE REGION?

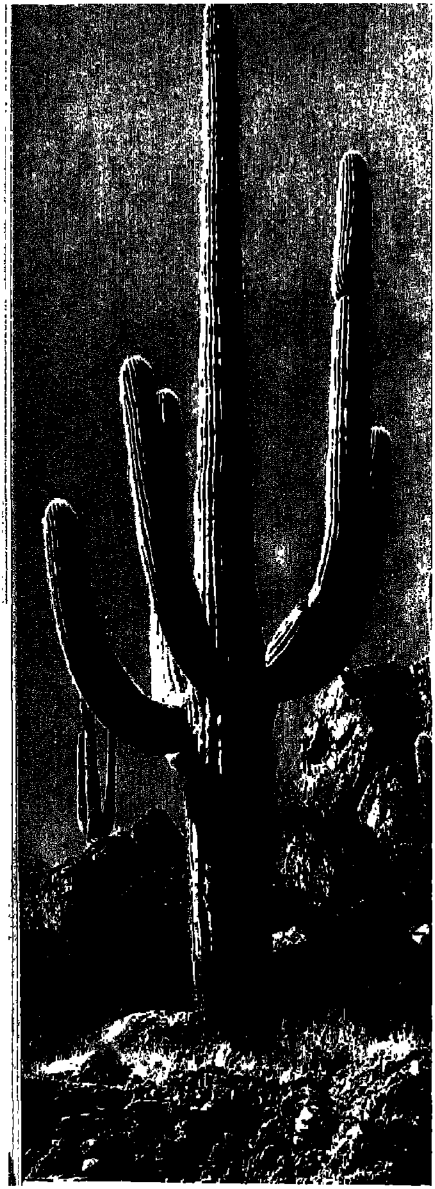
kept without spoiling for many months if moisture does not reach them. There is some water in the so-called dry foods. Dry beans contain about thirteen per cent water by weight. Cornmeal contains fifteen per cent; macaroni ten per cent; and wheat flour thirteen per cent water. When additional moisture reaches these foods, they usually mold or show other signs of having become unfit for human use. Bacteria (see page 175) are present in the air and sometimes on the foods themselves. These microbes cannot grow in an absence of moisture. When this necessary moisture is present, they begin to develop. Other organisms cause the fuzzy growth that we call *mold.*

Only a part of the water necessary for life and health is supplied by what we drink. Much of it is contained in the foods that we eat. As we have seen, many fresh fruits and vegetables are largely water, and even the driest of foods contain some of this necessary liquid.

### 6. How do desert plants and animals get water?

Some of you may have visited a desert region in the southwestern part of the United States. During most of the year these deserts are sandy wastes, the grays and greens of the foliage relieving the monotony of the light-colored sandy soil. Occasionally travelers see the desert when it presents gorgeous colors of yellow, pink, blue, and red. These brilliant colors are due to desert flowers that bloom for a short period in the spring following the winter rains. The deserts do not bloom every year because there is not always sufficient rain to make the seeds that lie in the sandy soil sprout or germinate and grow into flowering plants.

A desert has less rain than other regions of the earth. Cloudbursts may occur on the desert, but the rainfall is generally less than five inches dur-



SAGUARO, THE GIANT CACTUS OF ARIZONA, LIVES FOR MANY YEARS.

ing the twelve months of the year. This moisture soon evaporates from the sandy soil. The great scarcity of water is the outstanding characteristic of a desert.

Where such conditions prevail, we expect to find cacti of various kinds, the creosote bush, and sagebrush. Joshua trees, strange members of the lily family, are found in certain localities, and trees, such as the Palo Verde tree and the smoke tree, grow in other places.

Naturally, all desert plants must be able to live and grow with a limited supply of moisture. Some of these desert dwellers become very large. The Saguaro, or giant cactus of Arizona, lives for many years and grows into a huge plant. Many of these giant cacti are protected in the Saguaro National Monument near Tucson, Arizona. However, desert plants are usually stunted and dwarfed because of the very meager supply of water.

If we can examine some of the desert plants, we can easily understand how they are fitted to live in these lands of little rain. The leaves, roots, and stems of desert plants are unlike those of plants growing in other localities. Let us find out how these parts of the plants enable them to "carry on" in the regions of perpetual drought.

You read on page 107 that large amounts of water vapor escape into the air through tiny openings on the leaves of plants. Tons of water pass through these small openings on the leaves of plants growing on a single acre of moist soil during one season. Oak trees, corn, and wheat, for example, have large areas of leaf surface through which great quantities of water escape as water vapor. *Transpiration* is the name given to the escaping of water vapor from the leaves.

You can prove for yourselves that much water escapes through the leaves if you will take a piece of waxed paper —that from around a loaf of bread will do—into the home

MANY DESERT ANIMALS OBTAIN WATER FROM A BARREL CACTUS.

or the school garden. *Select some plant that is not too tall to be covered by a one-quart or two-quart fruit jar. Carefully cover all of the soil around the plant with the waxed paper so that the jar rests entirely on the paper. In a few hours the inside of the jar will be covered with water that came from the condensation of the water vapor of transpiration. Why is it important that the soil is completely covered with the waxed paper?*

The leaves of desert plants are fashioned in such a way that very little of the precious water escapes through them. The leaves of many desert plants are gray or grayish green, as they have a covering of a powdery substance, or a coating of fine "wool," which helps to prevent much transpiration. Some leaves are thick and leathery and have a varnished appearance. Other leaves are thick and fleshy so that water can be stored in them for future use. Some desert plants shed their leaves soon after the winter rains. In general, the leaves of desert plants are smaller and less numerous than those on plants that grow where water is abundant.

If we could visit a desert and dig up the roots of some of the plants, we should find that they extend far into the soil and spread out farther in all directions than do the roots of ordinary plants. The extensive root systems enable the desert plants to secure all of the available moisture from the soil and through these carry the moisture to the stems.

The stems of most desert trees and shrubs are very hard and covered with a thick skin or bark which prevents much water being lost through them. In most varieties of cacti, stems take the place of leaves. These stems are often provided with a waxy substance called cutin. Sometimes they have other forms of protection against the hot, dry desert air. The stems of cacti are frequently storage places or reservoirs for water.

We know that animal life depends upon the plant world for a food supply. Desert animals depend upon desert plants not only for their food supply, but in many cases for their water supply also. Desert snails and desert tortoises obtain their water from the juices of plants. The *rodents,* those small animals that are provided with sharp, gnawing teeth, also obtain their water from the stems of desert plants. Kangaroo rats and ground squirrels often gnaw into the stems of the barrel cacti and make use of the water that has been stored there.

Some animals do not eat vegetation but feed upon the flesh of other animals. They obtain their water from the flesh and blood of their victims. The red racer snake may swallow a whip-tailed lizard. The lizard had secured its water from insect food. The insects had secured their water from plants.

Large animals, such as the coyote and the fox, require such large amounts of water that they visit water holes, or the infrequent small streams which can be found on the deserts from time to time.

A surprisingly large variety of animal life is found in desert regions. Many kinds of plants are likewise found in these unfriendly places. All of them are able to live under these dry conditions because they waste none of the water available to them.

## 7. When does water destroy living things?

You have read of the living things that are found in the localities called deserts. These localities would be fertile, fruitful areas if more water could be provided. Water is necessary for all life, yet people sometimes experience the destruction of plants and animals because there is too much water. At such times we wish that some of the flood waters could be carried to the dry lands of the deserts. Engineers are learning to prevent floods and to irrigate the deserts.

Crops are usually destroyed when rivers overflow and their waters stand on the fields for a time. One exception is rice which thrives in flooded sections. The Dutch have saved thousands of acres of farm land by building dikes and pumping out the sea water from the enclosed fields.

*Vary the irrigation experiment suggested on pages 116-117,*

GREAT PROPERTY DAMAGE OCCURS WHEN RIVERS OVERFLOW THEIR BANKS.

*by observing the effect of too much water on a growing plant. Get some thriftily growing plant such as a potted geranium. Set the pot in a dish larger than the pot and some two inches deep. Place the whole in a sunny window. Keep the dish in which the pot sets filled with water so that the soil is always saturated with water. Observe the plant for three weeks. What happens?*

Animals, as well as plants, are destroyed by floods. Cattle and horses are often drowned when rivers overflow their banks and flood the pastures.

Floods not only destroy plants and animals, they have an indirect and very important effect on future crops. Tons of fertile topsoil are washed away when the Mississippi, the Ohio, and other rivers go on a rampage. This loss of plant food will result in smaller and poorer crops in the years

BOULDER DAM FURNISHES A LARGE SUPPLY OF WATER FOR IRRIGATION; IT ALSO PREVENTS POSSIBLE FLOODS.

to come. Great levees have been built along the Mississippi and other great rivers in order to prevent further damage. Previous flood damage has amounted in the United States to forty million dollars annually.

Floods always endanger the purity of a city's water supply. As a result, typhoid-fever epidemics occur if the Red Cross or some other relief agency does not enter the stricken area and administer typhoid vaccine to the flood victims.

No way has been found to prevent the great droughts like those which occurred in the middle-western states in recent years. Floods can be prevented to a great extent. Several great construction programs of recent years which will help to prevent floods are Boulder Dam in Nevada, Grand Coulee in Washington, and the Tennessee Valley Project. The water stored will be used, and the dangers from the overflowing of the rivers will have been lessened at the same time.

### THINGS TO DO

1. Fill a glass or beaker with ice water. Place it on a table in the room for about fifteen minutes. Does your observation confirm the experiment on page 109?
2. Make a list of ten solids, ten liquids, and five gases.
3. Make a bar graph to show the amounts of water that are contained in the foods that were mentioned in problem 6.
4. Make a collection of pictures of desert plants and animals, and display them on the class bulletin board.
5. Arrange to have some member of the class, who has a toy steam engine, bring it to class so that all may see how it operates.
6. If there is a water meter for your home, learn how to read it.
7. How many cubic feet of water is used in your home in

twenty-four hours? How many gallons? How many quarts?

8. Obtain a Fahrenheit thermometer, an ordinary room thermometer will do, and learn the temperature of the air in the room. Now cover the lower end of the thermometer with cotton that has been saturated with cold water. Take the thermometer reading five minutes later. Do your results check with the information given on page 114?
9. Bring two pieces of stale white bread into class. Moisten one piece and place it under a beaker or tumbler. Let the other remain dry and uncovered. Compare the results in two or three days. Write a paragraph based on your results on "Preventing the Spoiling of Foods in our Homes."
10. Taste the water from your faucet or well. Now boil some of the water for fifteen minutes and when it is cool taste it again. How do you account for its changed taste?
11. Write to a station of the United States Weather Bureau to find out the average yearly rainfall in your locality.
12. Make a collection of photographs, including kodak pictures taken by members of the class if possible, that show the destructive effects of erosion (water washing away the soil) on hillsides, vacant lots, and unplanted fields. Display them on the class bulletin board.
13. Make a large diagram to illustrate the journey of a raindrop from the ocean until it returns to the ocean.

### SOME THINGS TO REMEMBER

1. Water changes into water vapor by the process of evaporation.
2. Large quantities of water vapor escape from plants by the process of transpiration.
3. Clouds are composed of condensing water vapor.

4. Rain and snow fall from nimbus clouds.
5. Water exists in each of the three states of matter.
6. Water boils at a temperature of 212° Fahrenheit, or 100° Centigrade.
7. Water freezes at a temperature of 32° Fahrenheit, or 0° Centigrade.
8. Steam power has been widely used in many industries.
9. Both ice and steam are used to preserve food.
10. About two thirds of our body weight is water.
11. All food contains water.
12. Water is a widely used solvent.
13. Water is used about many homes for irrigation of lawns and gardens.
14. Desert plants grow in regions of little rainfall.
15. Many desert animals obtain both their food supply and water supply from desert plants.
16. Too much water in the form of floods may be very destructive.

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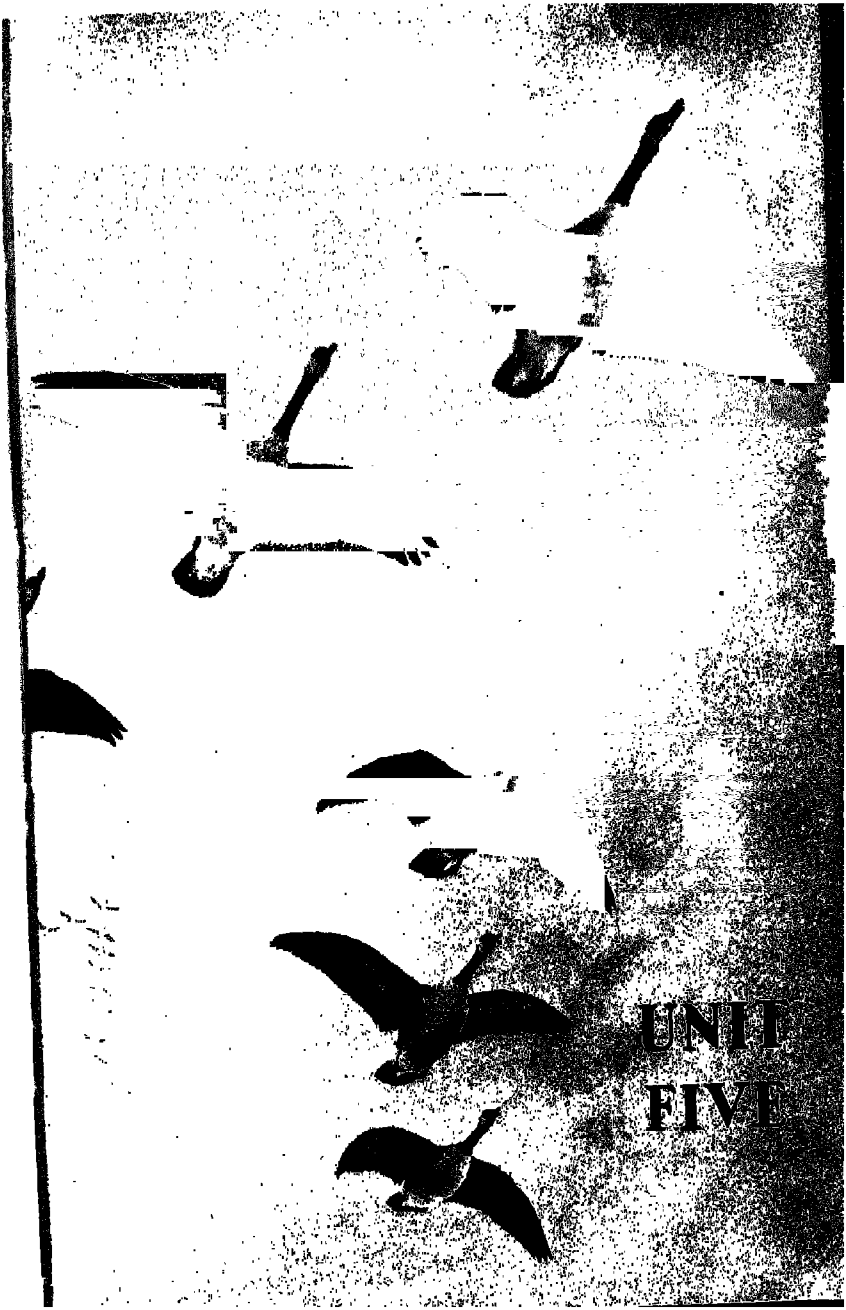


# UNIT FIVE

# UNIT FIVE

# The Living Things About Us

## WHAT THIS UNIT IS ABOUT

Did you see a bird, an unusual dog, or an interesting tree on the way to school this morning? Many people walk along the same block day after day and fail to notice such things as an especially beautiful tree, an oriole's nest, or a dragonfly hovering over a lily pool. Probably there are few people who could not discover a new plant or animal in a near-by yard or park.

Can you imagine a world without trees, flowers, birds, insects, and the great variety of animal life that surrounds us? Those who live in the country and in the smaller towns and cities are fortunate because they have an opportunity to know the plants and animals about them, and to call them friends.

There are city children who live in an absence of trees and grass. They are acquainted with few animals that might serve as pets. It was discovered a few years ago that there were many children in Los Angeles who had never seen a cow. So, two fine cows and their calves were taken in trucks to visit the children at the various schools. There are children in New York City who know nothing at first hand of wild flowers or any form of wild animal life.

We shall not enjoy the plant and animal life about us unless we learn to look for possible items of interest in all the plants and animals that we see.

# The Living Things About Us

## UNIT PROBLEMS

1. Was the earth always a fit home for living things?
2. What things are necessary for plant and animal life?
3. What kinds of animal life are found about us?
4. What kinds of plant life are found about us?
5. What are some undesirable plants?
6. How do present-day plants and animals differ from those of previous times?

### 1. Was the earth always a fit home for living things?

If we had visited the earth hundreds of millions of years ago, we should have found it a very inhospitable place for either plants or animals. There was no covering upon the earth's crust such as we call soil. There were no lakes, rivers, or oceans as we know them now because the rocky surface was so hot that the water evaporated as quickly as it fell. At one time in its early history the earth was surrounded by dense or heavy gases, so that it would have been impossible for any living thing to breathe. The drawing on page 132 is a scientist's idea of how the earth appeared when it was very young. Why do we see no evidences of plant and animal life in the picture?

Finally, after many millions of years the earth's surface cooled, parts of it became covered with soil and so began to be ready to be the home of living, breathing animals and plants.

AN ARTIST'S DRAWING PORTRAYS AN IMAGINARY LANDSCAPE A BILLION OR MORE YEARS AGO. THERE WERE NO TREES OR OTHER FORMS OF LIFE.

### 2. What things are necessary for plant and animal life?

There are things which are necessary for any kind of plant and animal life. All living things must have food. Plants obtain their nourishment from the soil, water, and air. All of the green plants must have sunlight in order to carry on their processes of food manufacture. Animals have a variety of feeding habits. Some of them, such as the deer, eat only parts of plants or vegetation. Others, for example the coyote and the wolf, eat only the flesh of other animals. Still others, such as bears, eat both plant and animal food.

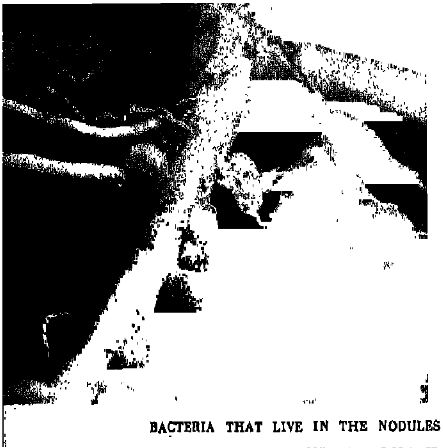
We have all seen plants wither and die because of a lack of moisture. Animals, too, cannot exist without water. Some

THE KOALA, LIKE THE KANGAROO, CARRIES ITS YOUNG IN A POUCH. THESE MAMMALS ARE AT HOME IN THE EUCALYPTUS FORESTS OF AUSTRALIA.

animals do not drink water but obtain it from their food. The koala bear in Australia uses eucalyptus leaves as a source of both food and water. Some of the animals that live on our arid western plains and on our American deserts obtain their water from the plant material that they eat.

As we have seen, air is also necessary for life. Food and water are sometimes scarce, but air is always plentiful even above the plains and deserts. Living things can do without food and water for some days, but the oxygen in the air is their most immediate need, and some forms of animal life die in a few minutes if deprived of this life-sustaining gas.

Temperature, or the degree of warmth, is important in the lives of all plants and animals. Some plants and animals



BACTERIA THAT LIVE IN THE NODULES ON THE ROOTS OF CLOVER AND RELATED PLANTS COMBINE NITROGEN FROM THE AIR WITH SUBSTANCES IN THE SOIL.

are found only in cold climates. Others require the heat of the tropics. Others are best suited to life in the temperate zones.

Temperature conditions in Florida and Southern California are very different from those in Minnesota and the Dakotas. We find oranges growing in warm areas where a wheat crop would be impossible. Wheat grows abundantly in the Dakotas and Minnesota where oranges would be killed by the low winter temperatures. The crocodile is an inhabitant of warm climates, while the polar bear is a native of the cold arctic regions. All plants and animals have certain temperature requirements, and many of them are killed by temperatures which are much above or below those to which they are accustomed.

You can try the effects of some of the factors necessary for life with living plants. *Sprout some bean seedlings. This can be done by soaking the beans in water overnight and then placing them in damp sand or sawdust until they have sprouted leaves. Carefully plant each bean in a small paper pot or plant them in water. If you plant in water, fill wide-mouthed bottles with water and tie a piece of stiff paper over the mouth. Cut a slit in the paper and allow the root of a bean seedling to drop through into the water. The bean will rest on the paper and the stem and leaves will grow above the paper.*

*Plant one of your seedlings in a dry bottle. How long can it live without water? Place one on the window sill in a sunny spot. Place another in a dark box, but keep the temperature* *near that of the room. Compare these two after several days. What conditions have affected the growth of these seedlings?*

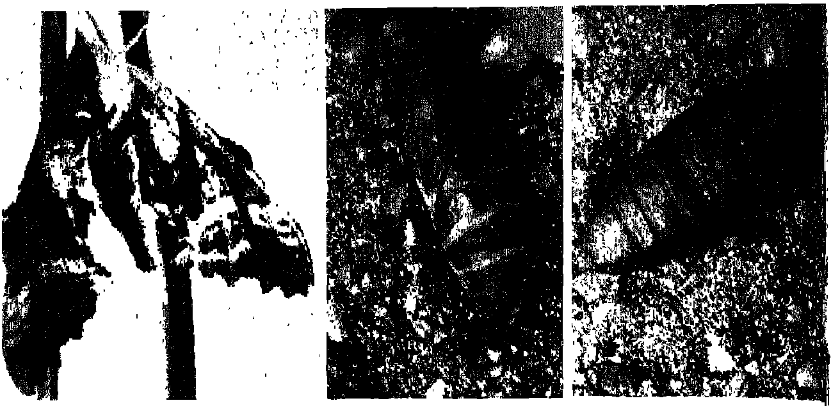
*Keep one bean seedling at room temperature for two days. Keep another in a refrigerator for two days. Compare these two. What was the temperature inside the refrigerator? Were there any factors about the inside of the refrigerator that made it less desirable than an open room for a bean plant?*

*Place one of the bean seedlings in a quart glass fruit jar. Put a rubber ring around the top and seal the jar tightly. Place the jar in good light and leave it sealed for several days. What happens to this plant? Explain all the things that happen to it.*

### 3. What kinds of animal life are found about us?

Our environment has been defined as our surroundings, or we may say that it is the region which surrounds us and our homes. It is evident that we shall find different kinds of animals in different environments. For example, a boy or girl living in a large city will not find all of the kinds of animals that are observed by children who live in the smaller towns and the country. On the other hand, city children who are able to visit a zoo will be able to see strange animals that rural children may know only through reading or through pictures. Because the distribution of animals depends very largely upon climate, we shall find that certain species of animals are found in places that have a peculiar or distinctive climate. Thus, animals are found in desert regions that are found in no other place, and certain other animals are characteristic of the mountains and the seashore.

Many animals are kept in zoos far removed from the natural environments of their kinds. What must the zoo keeper provide in order to be sure that these animals will



THE TOMATO "WORMS" THAT ARE FOUND IN GARDENS BECOME THE BROWN PUPAE, WHICH DEVELOP INTO THE ATTRACTIVE SPHINX MOTHS.

live? *Select some one animal of interest to you that is found in a zoo. For example, polar bears or tigers kept in zoos in our country are far removed from their original environment. For your animal, list the important things in its native environment that it must have. Now tell briefly how these things are provided in a zoo. Are there any other things that must be provided for your animal kept in captivity, that do not seem important for similar wild animals?*

*You should be able to obtain some help on this problem from W. T. Hornaday's "American Natural History," the school encyclopedia, or R. W. Hegner's "Parade of the Animal Kingdom." If you live near a good zoo, make trips to the zoo to check your findings by actual observations of the care given the animal of your choice.*

Some animals live in the soil, some in water, and some remain in the air above the earth for long periods.

*Earthworms* are valuable animals that live in the soil. They cultivate the soil by mixing the surface soil with that from below, thus bringing the under layers of soil to the top. Each earthworm turns over and mixes much soil each year. Soils that do not have any earthworm-inhabitants are often poor and do not provide a satisfactory home for plants. Earthworms not only help to improve the texture of the soil, but they furnish a considerable part of the food supply of some birds.

*Secure some earthworms. Find out if they see, smell, and taste. What do you need to know about the environment of earthworms in order to find them? Where is an earthworm more likely to find food? Ask an experienced fisherman.*

The soil frequently contains *insects* in various stages of development. The brown pupa case of a hawk moth, sometimes called a "tomato worm" in its larva stage, lives in the soil. Cutworms which are the larvae of certain beetles are also found in the soil. Cutworms do great damage to young and tender plants.

*Find some "tomato worms" on tomato plants or the brown pupa cases in the soil and watch them complete their life cycles.*

Ants also live in the soil. Their nests are frequently near the surface and consist of a number of irregular chambers or rooms. Ants may be very troublesome if they get into houses. A few kinds do great damage to growing fruits and vegetables.

The different forms of life that are found in the water illustrate how certain plants and animals are fitted to live under the conditions of temperature, moisture, and food supply that are found in their particular environment. Those who live near a river or a pond have a splendid opportunity to study the plants and animals that live in the water. Hundreds of kinds of living things may be found in a pond during the spring and summer. Some of these are so small that a microscope must be used in order to see them.

You can easily obtain considerable information for yourself about the life in fresh water ponds or streams near you. *Arrange a small aquarium. Use a straight-sided glass jar that will hold at least a gallon. Place some clean washed sand*

*and a few pebbles in the bottom. Fill the jar with water from the nearest creek or pond. Find some small water plants and plant these in the sand in the bottom of the jar. If you do not find suitable ones, such a plant as elodea can often be bought from a florist. Cover the jar with a pane of glass. As you find them, add water snails, frog eggs, small tadpoles, and water insects. From time to time examine drops of the water under a microscope. Report what you can find. After six weeks make a report on the things that have been found growing in the jar.*

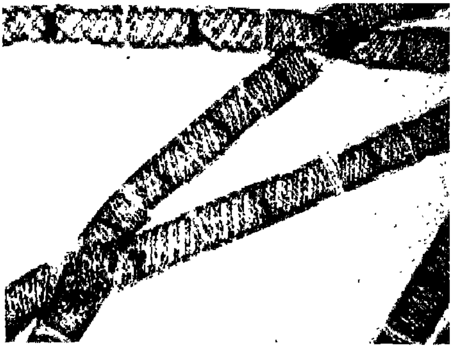
A drop of water may contain a dozen or more small animals that move about rapidly. One of the most common of these one-celled animals is shaped like a slipper and is called *paramecium.* Others are round, and still others are shaped like a bell. There may be a small zoo in a single drop

THIS WATER LOOKS QUIET, BUT IT IS FULL OF LIFE.

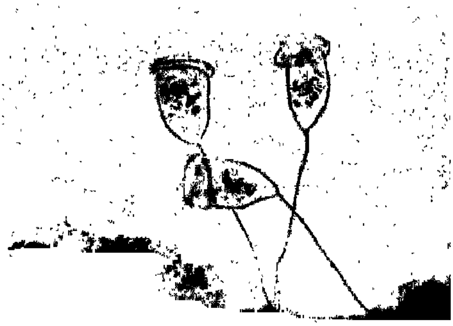
of water. Some of these microscopic animals are shown on this page.

Animals that live in the water, regardless of their size, depend upon green water plants for their food and much of their oxygen supply. Many water animals feed on pond scums, or *algae,* which are simple forms of plants found in many ponds, lakes, and pools during the warmer months. The algae float on the water and sometimes form an almost solid covering over it. When examined with a microscope, the algae show many interesting and beautiful patterns.

The larger aquatic plants are more familiar to us than the small microscopic ones. Water lilies, cattails, and reeds are frequently found in ponds, lakes, and slow moving rivers where their roots are anchored to the muddy bed of the lake or stream. Water lilies are among the most beautiful of our flowering plants. Their roots are anchored in the mud beneath the water and their large leaves and flowers are

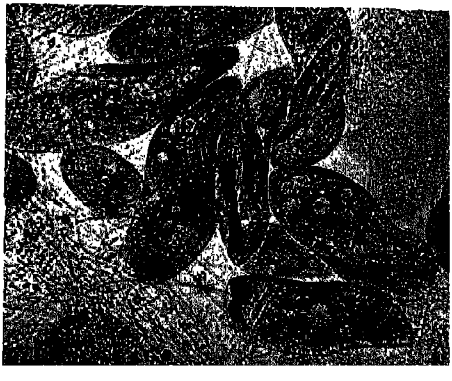


SPIROGYRA IS A WIDELY FOUND FORM OF GREEN ALGAE.



VORTICELLAE ARE ONE-CELLED ANIMALS. DOZENS CAN BE CONTAINED IN A DROP OF WATER.

PARAMECIA ARE MINUTE ONE-CELLED ANIMALS.



buoyed up (supported) by the water. In a dry season water lilies in some places fill the bed of a small stream or pond.

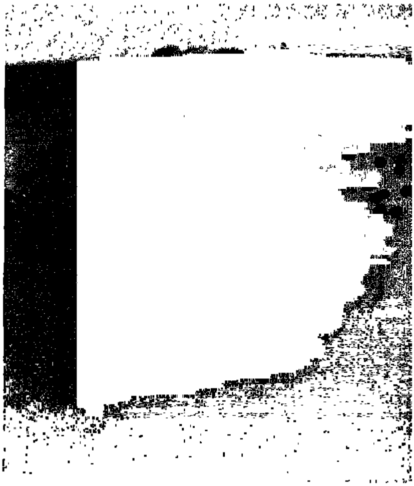
Animals that have a bony skeleton are called *vertebrate* animals. Several kinds of vertebrate animals are found in the water. Fishes obtain both food and air from the water. As we have learned, gills in a fish serve the same purpose as lungs in higher animals.

Other vertebrate animals which spend a part of their lives in the water are called *amphibians*. Frogs are amphibians. The female frog lays large masses of eggs in quiet water. There are sometimes two to four thousand eggs in one egg mass. Why do you think so many eggs are produced? The tadpoles that hatch from these eggs look more like small fish than small frogs. They breathe by means of gills. Soon the hind legs develop, and after a few weeks the front legs appear. The tail gradually disappears; the small frog breathes with its lungs and is able to live on land. If you have ever watched frogs develop through these different stages, the pictures on page 141 are familiar to you. Several years must pass before some species, or kinds, of frogs become full-grown adults. Toads, newts, and salamanders are other amphibians you may find in the water during the time of the year that ponds and small streams offer a favorable environment for these animals.

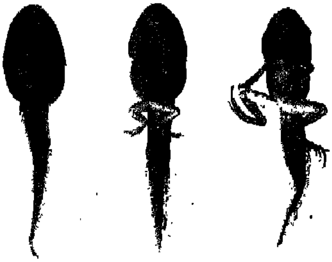
*Plan to get some frog eggs in the spring. Place these in an aquarium like that described on pages 137-138. Watch them as they develop. From day to day examine some of the eggs under a good hand lens to see how the eggs begin to divide. After the tadpoles have hatched watch for the changes that take place as they grow.*

To better understand the animals in our environment, it is convenient to arrange them in related groups or *orders*. An order is a division of the animal world that contains a rather large group of related families. We know that human beings are grouped into races, nationalities, and finally families. It is necessary that animals be grouped in some way to show their similarities and relationships. The fishes, amphibians, and insects mentioned in the preceding pages belong to large divisions of the animal kingdom that are known as orders.

Birds are sometimes divided into four groups, depending upon how long they remain in a locality. *Residents* remain throughout the year. Summer residents spend the warm months in one region and migrate southward as winter approaches. Winter residents spend the winter in one locality and migrate northward for the spring and summer months. *Transients* are migratory birds that may stop over for a long visit in a locality, or may remain only a few days much as a tourist stops for a visit in a town or city. Three hundred and fifty-one species of birds have been seen and recorded somewhere in the state of Kansas during some season of the year. Of this number, fifty-one are residents, one hundred and twenty-five are summer residents, thirty-six are winter resi-

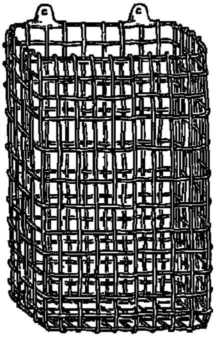


THE COMMON FROG EGGS ARE LAID IN LARGE MASSES.



POLLYWOGS BEAR LITTLE RESEMBLANCE TO ADULT FROGS.

FROGS SPEND MOST OF THEIR LIVES IN THE WATER.



SUET IN A WIRE CONTAINER PROVIDES FOOD FOR BIRDS.

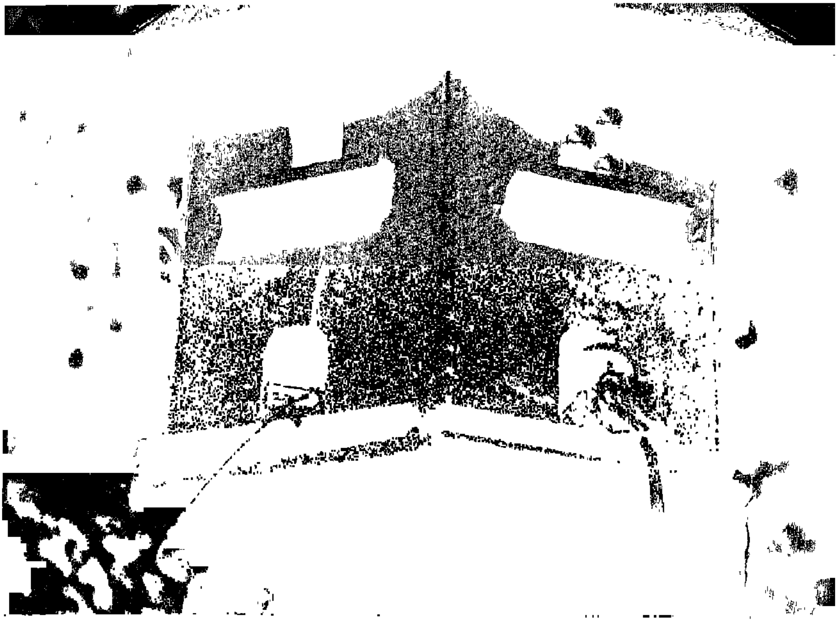
dents, and one hundred and thirty-nine are transients.

Winter is a good time to begin to know some of the birds that are with us as residents and transients. The dense foliage that conceals the birds at other seasons of the year falls from the deciduous trees (see page 170) and the birds are easily seen on the bare limbs. Sometimes the snow furnishes a revealing background for them. During the winter months when food is scarce, the birds become bold enough to come up to a feeding station placed outside a window to enjoy the suet or grain provided for them.

Woodpeckers, nuthatches, chickadees, and kinglets are insect-eating birds that are attracted to the suet during the cold winter months. Tree sparrows, slate-colored juncos, goldfinches, and cardinals depend upon seeds for the bulk of their food. They soon learn to visit a feeding station where seeds of sunflowers, pumpkins, millet, hemp, rye, barley, and wheat are waiting for them.

*Put out pieces of suet for the insect-eating birds that are about your home in winter. Make a list of the kinds of birds that visit your feeding station during a period of two weeks.*

In the summertime we may expect to find robins and bluebirds, members of the thrush family, near our homes. The robin is one of the common birds in the United States. Robins nest in low-branching trees, in shrubbery, or in vines. The food of robins consists of cutworms, caterpillars, moths, grasshoppers, beetles, earthworms, and fruits. These birds should not be begrudged the cherries and strawberries that are their



THIS PAIR OF ENGLISH SPARROWS HAS APPROPRIATED THE NESTING PLACE THAT WAS PROVIDED FOR MORE DESIRABLE BIRDS.

special delight, for many injurious insects are eaten to satisfy their huge appetites, thus protecting garden plants and trees.

The English sparrow, or house sparrow, was introduced into the United States from England and is found throughout the United States. Everywhere it is considered to be a pest. These small birds commonly live in towns and cities as well as in the country. They destroy fruit as well as buds on cultivated trees, shrubs, and vines. They eat more grain and less insect food than any native sparrow. They destroy the nests and eggs of other useful birds. Because of their filthy and destructive habits, the English sparrows, unlike the robins and the bluebirds, are not given protection in any of the states.

Baltimore and orchard orioles in the central and eastern states, and the Arizona hooded and the Bullock orioles in the

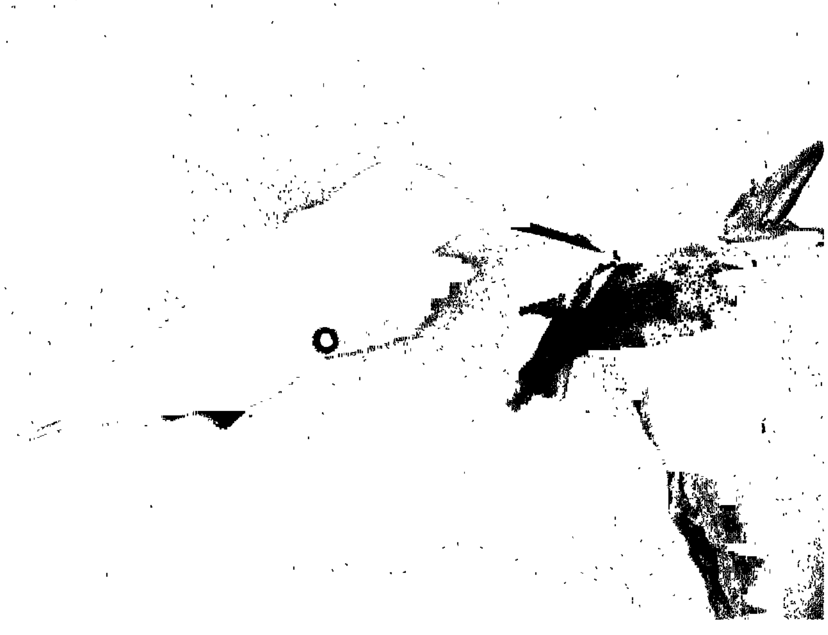
Southwest, are gorgeous summer residents in any yard or garden. The food of orioles consists largely of insects and fruit.

Different species of hummingbirds are found in various sections of the United States. In the eastern states the ruby throat is more or less common. In the West, the Anna hummingbird is frequently observed feeding from flowers that have tubular blossoms. Hummingbirds are the smallest of the many species of birds. Nectar from flowers is supposed to be their chief food, but examinations of their tiny stomachs have shown that insects and spiders furnish nearly ninety-five per cent of their food. Observation will enable us to determine the food habits of the different birds around our homes.

*Make a record of the dates when robins, bluebirds, meadow larks, killdeer, blackbirds and other species of birds are first seen near your home in the spring.*

Where would you look for the homes or nests of the different species of birds? As a rule, birds build their homes near their food supply. So, if we know something of a bird's

NECTAR IS A FAVORITE FOOD OF HUMMINGBIRDS.



feeding habits, we have some idea of where to look for the nest. Many species of birds build their nests on the ground or in bunches of grass. The bobwhite, horned lark, killdeer, meadow lark, pheasant, spotted sandpiper, and song sparrow nest in fields. The black and white warbler, hermit thrush, ruffed grouse, towhee, whippoorwill, and woodcock hide their nests on the ground in the woods. The bittern, black duck, coot, loon, marsh hawk, snipe, Virginia rail, and Maryland yellowthroat nest in marshes.

Some of the ground-nesting birds have clever methods of protecting their eggs and young. The killdeer, for example, deserts her nest when enemies approach. The eggs and young are colored so much like their surroundings that they escape the notice of intruders. Horned larks, vesper sparrows, and meadow larks protect their nests in a similar way.

Some birds protect their nests by pretending they are dead or dying. When an enemy approaches within a few feet of a mourning dove's nest, the bird flies to the ground and drags along like a seriously injured bird. If a person, dog, or cat starts toward the bird, it flies away and the location of the nest remains a mystery. Quails, nighthawks, ducks, and many other ground-nesting birds protect their nests or young by this method which is called *concealment by abandonment.*

Burrows in the ground are the homes of some species of birds. Bank swallows, cliff swallows, kingfishers, and rough winged swallows successfully conceal their nests in burrows in banks that border along a stream.

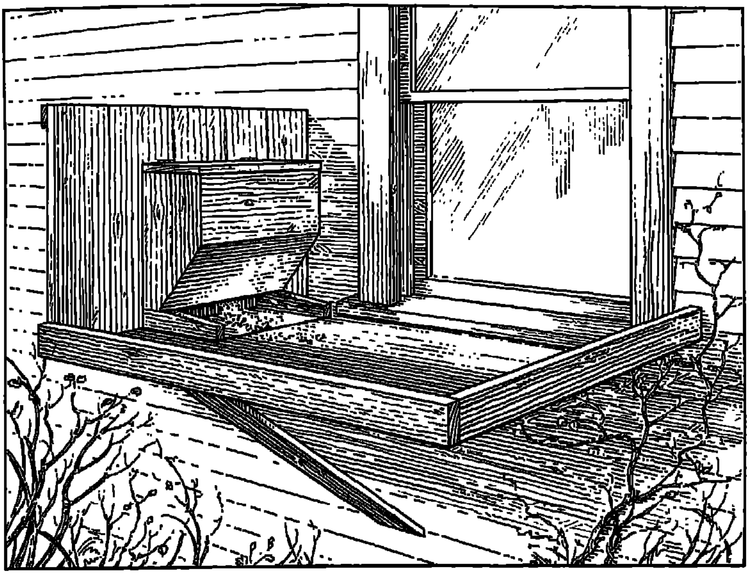
Most of the song birds nest in trees and shrubbery. They feed largely upon insects that live on trees and shrubbery, or sometimes on the fruits of plants near the nesting site. The various species of vireos suspend their nests from bushes and trees, as do the orioles. Robins' nests are built in trees as a rule and consist of grasses and mud. The hummingbirds, goldfinches, brown towhees, scarlet tanagers, cedar waxwings, red-breasted grosbeaks, blue jays, and cardinals are other bird-neighbors that conceal their nests in the leafy branches of some tree or shrub. When the leaves fall from the deciduous trees, the empty nests become visible.

Holes in trees and bird boxes furnish homes for other species of birds. The woodpeckers drill holes in trees and lay their eggs in the cavities without building a nest of grasses, feathers, or other materials. The house wren, bluebird, tree swallow, and chickadees build their nests in old woodpecker holes, in natural cavities in trees, or in bird houses with similar openings. Sparrow-hawks and screech owls use cavities in trees that were made by flickers, members of the woodpecker family. They lay their eggs in these homes without going to the trouble of building a nest. Barred owls, great horned owls, and wood ducks use larger natural cavities for their homes.

Other birds establish their homes in very strange places. Gulls, pelicans, and cormorants build their nests of seaweeds on some rocky island high above the sea. Barn swallows build homes of mud under the eaves of buildings. Cliff swallows frequently attach their mud houses to bridges. Barn owls often choose the belfry of a church, a deserted attic, or other abandoned building for a site in which to rear their young. The American dipper or water ouzel finds a home among the stones in some small stream that never dries up.

*Make a collection of abandoned birds' nests in the fall. Label each one carefully with the name of the species of bird that built it.*

We can invite the birds to make their homes near our own by providing food supply, water, and natural cover for the kinds of birds we desire to attract. If we have trees or shrubbery in our yards we expect some of the song birds to



A BOY HANDY WITH TOOLS CAN EASILY MAKE A WINDOW-SHELF FEEDING STATION FOR SEED-EATING BIRDS.

nest there, especially if we provide shrubs that produce fruits eaten by birds. If we want to become acquainted with a family of wrens, bluebirds, or chickadees, we can furnish a suitable home for their use. There are few more interesting experiences than having bird friends live in our yards and gardens.

One of the reasons we want the birds to build their homes near our own is that we enjoy their calls and songs. People used to believe that birds sing to charm or captivate a mate. The females of most species pay little or no attention to the songs of the male birds. Today, people who make a scientific study of birds tell us that singing during the nesting season is to announce to the bird world in general that certain territory has been claimed and that all other males are to keep out. Birds lay out the boundaries of their home sites much as miners stake out their claims. Of course a bird does not put a fence around his chosen territory, but his song from the nearest point establishes his claim.

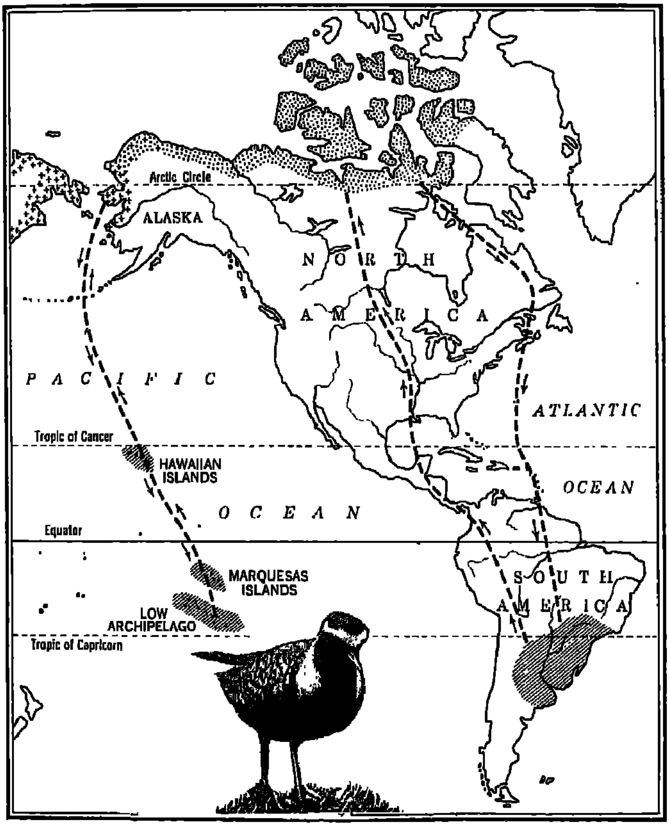
Bird territories are of two kinds: *nesting* and *feeding* territories. In some instances the nesting and feeding grounds are the same. In cases where birds nest in colonies, as for example birds that nest on a small island, or cliff swallows that plaster their mud nests close to their neighbors, the feeding territories must be different from the nesting territories.

*Try to determine whether the feeding and nesting territories of the birds around your home are the same. Watch for the arrival of some of the birds in the spring and listen for the songs of the male birds as they select their territories.*

We are familiar with the fact that there are relatively few birds with us throughout the year. They appear in the spring and disappear in the fall. The movements of birds to and from their nesting grounds is called *migration*. Early peoples did not understand the disappearance of the birds in the fall and their reappearance in the spring. They had many strange ideas concerning them. Some thought they had gone to the moon. Others believed that the swallows sank into the mud of river bottoms. Even today some people in Europe think that small birds cross the Mediterranean Sea on the backs of storks.

The Bureau of Biological Survey, of the United States Department of Agriculture, has gained much accurate information about bird migration during the last forty or fifty years. This bureau has stationed over North America hundreds of people who catch birds in order to place small metal bands around their legs. They then release the birds hoping that they may be recaptured and the number on the tag noted. In this way exact information of their travels will be gained. Some of the birds travel thousands of miles between their summer and their winter homes. Many birds fly from North America to South America in order to have a warm winter home where food is plentiful. The bands on the birds' legs tell us that many of them make the same journey year after year.

Banding gives accurate knowledge about the travels of birds. An American tern, banded off the coast of Maine on



THE GOLDEN PLOVERS THAT BREED IN THE ARCTIC REGIONS MAKE A NON-STOP FLIGHT FROM EASTERN CANADA TO SOUTH AMERICA. THEY RETURN BY WAY OF THE MISSISSIPPI VALLEY. THE PACIFIC STATES PLOVERS THAT BREED IN ALASKA MAKE A NON-STOP FLIGHT TO AND FROM HAWAII, THE MARQUESAS ISLANDS AND THE LOW ARCHIPELAGO.

July 3, 1913, was found dead in British West Africa in August of the year 1917. Two black-headed gulls were banded at Rossitten, Germany, on July 18, 1911. One of them was captured in the British West Indies in November 1911, and the other was found in Vera Cruz, Mexico, in February 1912.

The migration routes of the golden plover are shown on the map on page 149. Trace this long journey on the map. Golden plovers nest from Alaska to Hudson Bay and, in the autumn, they again gather in the region of Labrador.

A more familiar bird, the barn swallow, nests over most of North America. It spends the winters in South America. Many people almost envy the birds that are such world travelers.

We might expect the birds to fly east and west across the United States in their migrations. The Rocky Mountains provide an almost impassable barrier. Therefore, migratory routes are generally in a north and south direction. The birds of the western United States do not make as long migratory journeys as do the birds of the eastern states.

Many of the small birds travel at night. In this way they escape their enemies, the hawks and others of the birds of prey. The tiny hummingbird can outdistance any hawk, and can safely fly by day. Larger birds, such as the crows and hawks, find it safe to travel during the daytime. Great flocks of migrating birds can usually be seen during the spring and fall. Geese fly in a characteristic V-shaped formation, and ducks travel in an irregular formation in which one bird is the leader. You will enjoy keeping a record of the dates of arrival and departure of different species of birds during the year. *Select ten birds that you can easily identify. Make a record of the last date in the fall on which you see each of these kinds of birds. Post your list on the classroom* *bulletin board. Are any of your ten birds permanent residents? Can you prove it? How will you prove your case?*

For many years students of birds have tried to find an explanation of the causes of bird migration. Several explanations have been offered. None of them seems entirely satisfactory. Probably the best one is that birds migrate when their food supply becomes scarce to a region where there is a plentiful supply. This suggested cause is supported by the fact that many birds take considerable time in migrating, stopping along the way when they find a good food supply. Again, some birds that we think of as migrating are often found during mild weather in the winter in the places where we expect to find them in summer. We often speak of bluebirds and robins as announcing the coming of spring. And yet, bluebirds and robins are often found in the central part of this country in December, January, and February. Apparently some birds that are commonly thought of as migrating remain with us in winter if they can find food.

*An interesting problem for work, if you are interested in birds, is that of trying to find out if the resident birds you see about in the winter are the same birds found in your yard or neighboring park in the summer. For example, in some parts of the country you can see jays, cardinals, crows, and starlings throughout the year. But, are the jays that you see in your yard or the nearest park in the winter the same jays that you see in these places in the summer? Can you work out a way to solve this problem for some species of bird that interests you?*

The birds are the chief natural enemies of the insects that cause us so much trouble. Insects eat at least one tenth of all the crops that are grown, destroy trees, wood products and clothing, and cause diseases among animals and human beings.

MONARCH BUTTERFLIES MAKE LONG MIGRATORY FLIGHTS. THIS ONE IS RESTING ON A THISTLE.

There are thousands of kinds of the six-legged pests. Some authorities state that there are 500,000 species, and others estimate that there are a million. When we think of the myriads of representatives of each species of insect, as, for example, flies and mosquitoes, we can readily believe that the insects are more numerous than many forms of higher animal life.

Many people have made large insect collections. The butterflies and moths are probably the most universally collected order of insects. The word *Lepidoptera* means scale-wings. These insects attract attention because of their bright colors and their interesting life cycles.

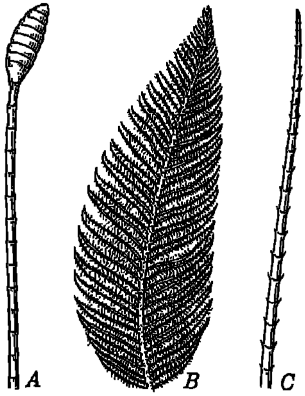
The monarch butterfly is typical of this order of insects. It is a reddish-brown butterfly with a peculiar habit of migrating in large swarms. The illustration shows a common thistle head with one of many thousands of the insects resting during a migratory flight. Unlike most of the insects, the monarch butterfly spends the winter season in the adult stage.

In the spring the female butterfly lays fertilized eggs on the leaves of milkweed plants. In a few days the eggs hatch into caterpillars, or *larvae*. The larvae feed on the milkweed leaves. The caterpillars eat so greedily that they grow very rapidly. They molt four times as they become too large for their skins. The old skin cracks open, and the caterpillar emerges in a new and larger skin after each molt.

Just before the fourth and last molt, the caterpillar attaches itself to a leaf or stem, and for a few days before it molts it is suspended, head down, by a bit of silk. Then it is no longer a caterpillar, or larva, but a *chrysalis* or *pupa*, without legs or mouth parts. The chrysalis is very beautiful, being a yellowish-green color with golden spots. A wonderful change occurs within the pupa case. Wings, new legs, and new mouth parts are developing while the chrysalis hangs to the milkweed plant. In a few days the pupa case opens and the adult butterfly emerges. The wings are damp and wrinkled, but in a few hours they become dry and smooth and the monarch butterfly flies away among the flowers in search of food.

We can always decide whether an adult insect is a moth or a butterfly by examining the antennae, or "feelers."

The antennae of a butterfly always have small knobs at the ends. The moth's antennae may be straight, curved, or feathery, but they never have



THIS DRAWING SHOWS THE FEELERS, OR ANTENNAE, OF BUTTERFLIES AND MOTHS; A, BUTTERFLIES; B AND C, MOTHS. THESE ARE GREATLY ENLARGED.

THE CECROPIA IS ONE OF THE HANDSOMEST OF THE MOTHS FOUND IN THE UNITED STATES. HAVE YOU EVER SEEN ONE OF THEIR COCOONS ATTACHED TO A TWIG OR FENCE?

the small balls or knobs. A magnifying glass will help you in observing these features.

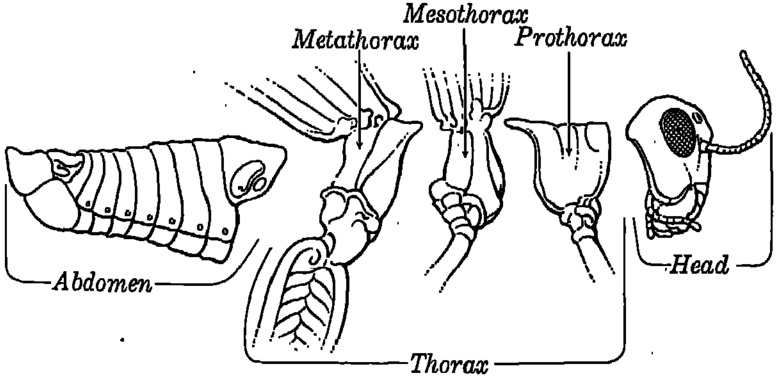
The *cecropia moth* is one of the largest and most beautiful of the moths found in the United States. The antennae are feathery. These moths develop from caterpillars that feed upon various trees and shrubs. After several molts the caterpillar spins a cocoon which is attached to the twig of some tree or shrub. During the cold winter months the *pupa* lives in the silken cocoon from which the reddish moth emerges in the spring. The fertilized eggs are laid on the leaves which will serve as food for the young caterpillars.

*In the fall, collect the eggs and caterpillars of different kinds of moths and butterflies. Keep the caterpillars well supplied with their favorite leaves, and watch them complete their metamorphosis or life cycles.*

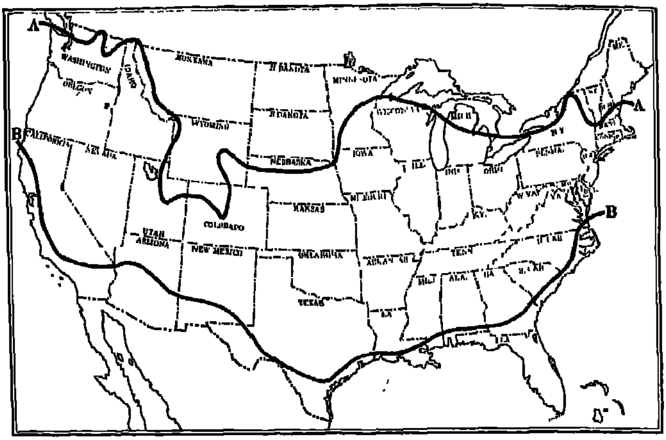
Another familiar insect is the grasshopper. Grasshoppers belong to an insect order which has straight wings. Different species of these insects are found throughout the United States. All have the same life history and general structure.

In the fall the female grasshopper digs a hole in hard ground where she lays a mass of eggs. In the spring the eggs hatch into small wingless creatures called *nymphs.* The nymphs resemble their parents so much that it is very evident they are young grasshoppers. The nymphs molt several times. As they grow the adult winged insect emerges at the final molt.

The body of a grasshopper shows the same three divisions that are seen in all insects — head, thorax and abdomen. The



THE GRASSHOPPER, LIKE ALL ADULT INSECTS, HAS THREE BODY DIVISIONS—HEAD, THORAX, AND ABDOMEN. WHAT IS THE WORK OF EACH DIVISION?



TERMITES DO GREAT DAMAGE IN THE UNITED STATES. THEY ARE USUALLY FOUND IN THE AREA BETWEEN THE HEAVY LINES AS INDICATED ON THE MAP.

wings and legs are attached to the thorax. The abdomen consists of a series of jointed rings. Tiny openings in the abdomen called spiracles are used in breathing. See page 90.

Grasshoppers are equipped with the means of escaping many of their natural enemies. Their long legs enable them to jump considerable distances, and some have strong wings for flying. Many enemies overlook them because their color resembles the grass and the leaves. This means of escaping enemies is known as *protective coloration.* They have large eyes in their heads. Their ears, strange to say, are located on the sides of the body.

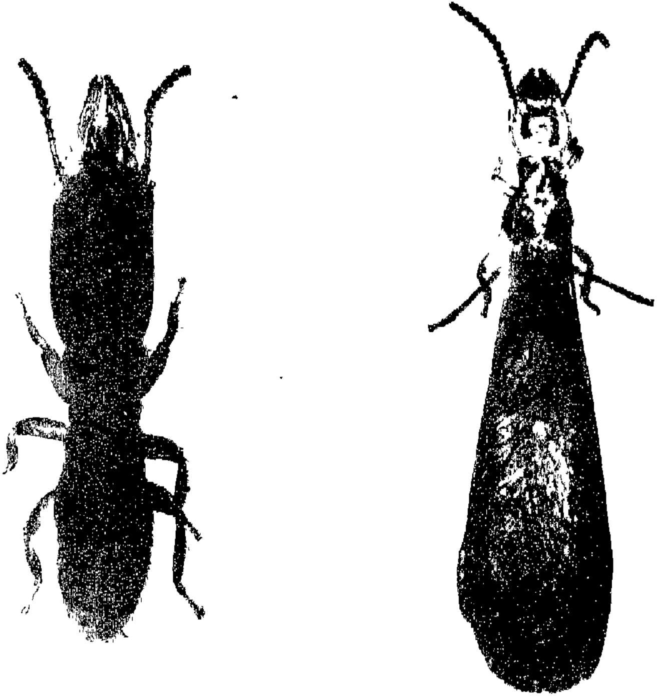
The grasshopper because of its size is a good insect to use to get some knowledge of how insects are constructed. *Collect enough large grasshoppers for each member of the class to have one. Kill them by placing them in an airtight compartment filled with the fumes of ether or common fuel gas. Note the three major divisions of the insect's body. How many legs has it? How does it differ from a spider in this respect? Can you find the spiracles through which the insect breathes?*

*Examine the antennae. Note the mouth parts. Cut a grasshopper in two. Note that there is no bony skeleton of the kind found in vertebrates. The grasshopper is held together by the outer horny "shell" which takes the place of a skeleton and serves as an outer protective covering at the same time.*

*Termites* are insects more widely distributed than many people suspect. (Map on page 156.) They are sometimes incorrectly called "white ants."

Termites are natives of tropical countries, but have made their way into temperate climates. Unlike other insects, termites eat only wood or materials made of wood. They sometimes eat away the wood in houses and other buildings, so that the floors sag and the structures become unsafe for use. In some of the states thousands of telegraph and telephone poles must be replaced each year because termites destroy

SOME TERMITES HAVE WINGS AND OTHERS DO NOT. THE SOLDIER TYPE IS SHOWN TO THE LEFT; THE WINGED ADULT TO THE RIGHT.



them. As they make small tunnels in books when eating the paper, they sometimes do great damage in valuable libraries.

Termites are usually wingless insects. Wings develop on the mature males and females, so they can fly away to start new colonies. A nest is started by a single pair of termites, a king and a queen. Some species nest in the ground and others in wooden structures or in a log. The queen lays fertilized eggs at an estimated rate of ten million a year. There are three kinds of eggs: some develop into kings and queens; some into workers; and some into soldiers.

The eggs hatch into nymphs which immediately start to dig tunnels in order to enlarge their homes. The termites remain as nymphs until they have molted many times. One species molts nineteen times. Kings and queens are sometimes an inch long, and have long delicate wings. The soldiers are wingless and are always blind. They have long, powerful jaws that are used to protect the colony from enemies. The workers, as the name indicates, carry on most of the necessary activities of the colony.

Dragonflies, which belong to the order *Odonata,* are among the most beautiful of our insects. You may see them in the summertime flying near a stream, lake, or lily pool. They have shiny, iridescent wings that vary in color from bluish-black to red. Some have black wings that are spotted with white. There are many species of dragonflies. The hero dragonfly, seen in the Mississippi Valley, has a wingspread of five inches. Fossils of prehistoric dragonflies have been found with a wingspread of twenty-five inches. These insects must have flown with great power and speed. Today, dragonflies travel in great swarms, flying at a speed of seventy or eighty miles an hour.

Dragonflies feed upon mosquitoes. The female dragonfly deposits her fertilized eggs in water, so that the nymphs which hatch from the eggs can find their favorite food of mosquito larvae or wrigglers. The nymphs live in the water among plant leaves or stems, or on the muddy bottoms of ponds, pools, or sluggish streams. The nymphs are green, brown, or black. Many are able to escape their enemies because this protective coloring renders them inconspicuous. The nymph molts several times and finally crawls up on a stick or leaf above the water. When it has dried off, the skin splits open along the back, and the dragonfly makes its way into the air and sunshine. It crawls out on the stick and rests quietly while the crumpled-up wings expand and harden in the air. Then it is ready to fly about in search of mosquitoes which are taken from the air.

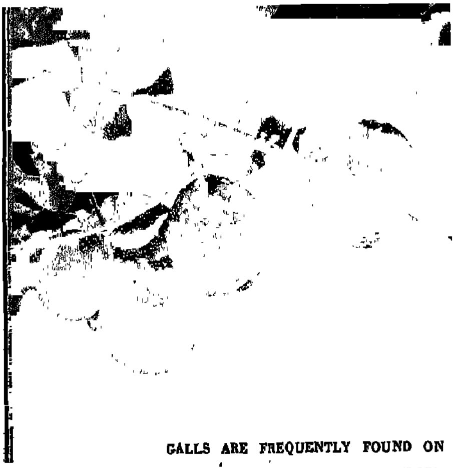
Termites, grasshoppers, most moths, and butterflies are destructive insects. The dragonflies are entirely beneficial because they are the most effective natural enemies of mosquitoes.

How many of you are familiar with the so-called "oak apples"? Do you know why these "apples" grow on oaks, willows, and other trees and plants? What would you find inside the "apple" if you should cut one open?

The galls on goldenrod are peculiar growths of plant tissue around the place where a flylike insect injured the tissue of the stem when she laid an egg there.

The egg hatched in about a week, depending upon the warmth of the air, into a small larva. The larva continued to grow for several weeks as the gall became larger and larger. During this time the larva gnawed a hole (to be used later on) from the center to the thin outer skin of the gall. The skin of the larva hardened into a brown shell and the pupa was formed. Later the pupa case opened and the adult insect crawled through the gall hole made when it was a larva.

Gall insects of different species also produce growths on



GALLS ARE FREQUENTLY FOUND ON DIFFERENT KINDS OF OAK TREES.

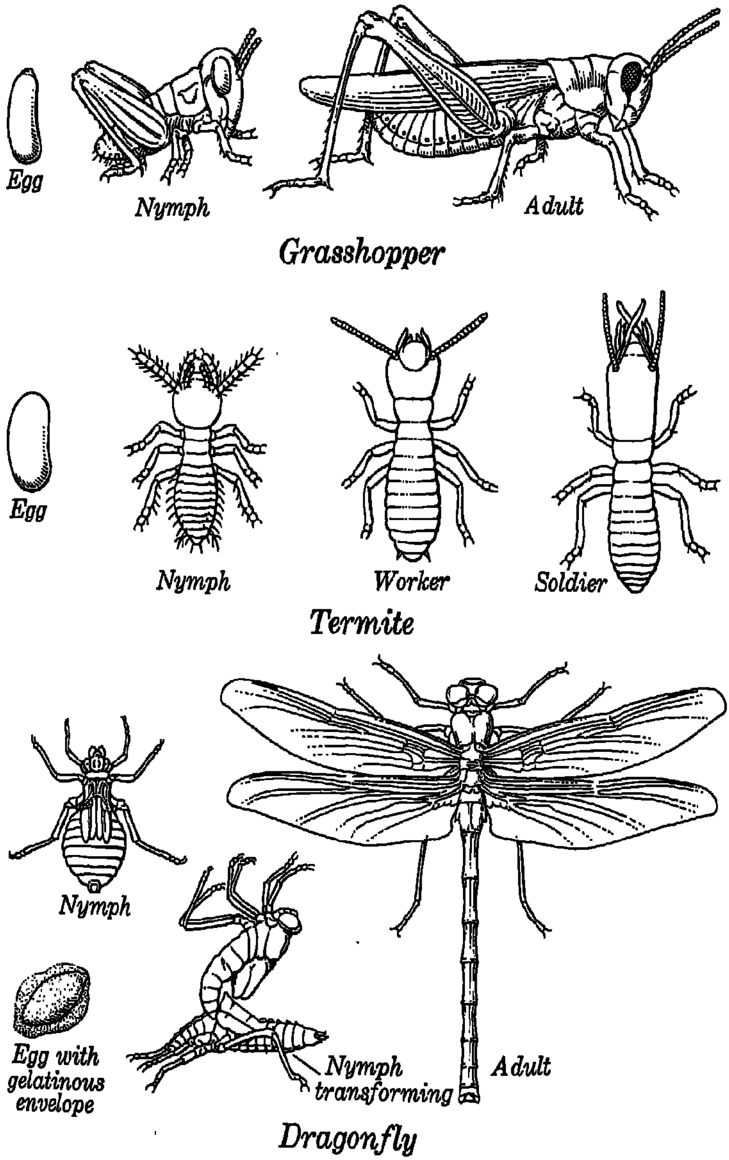
the long stems of poplar leaves, and on oak trees. Other galls are due to wasps which lay their eggs in the stems of plants.

The housefly is among the most frequently seen of our insects. This kind of insect is characterized by having two wings. The female fly lays her fertilized eggs in stable-manure, garbage, or other refuse. If our surroundings are clean and sanitary we shall have fewer flies to annoy us.

One female fly may lay several lots of eggs during the warm months. There are from one hundred and twenty to one hundred and fifty eggs in each lot. In from eight to twenty-four hours, or longer, depending upon the temperature, the eggs hatch into the small white larvae frequently called maggots. In five or six days the larvae develop into pupae. The pupae are brown and somewhat resemble small seeds. In another five days, if the weather is warm, the adult flies hatch from the pupa cases. Thus, an egg may be transformed into an adult fly in ten days. In one season there may be six or eight generations. The following table shows how these disease-carrying insects multiply in one month:

| | | | |
|---|---|---|---|
| June 1 | One adult fly lays | 120 | eggs |
| June 10 | 60 flies lay | 7200 | eggs |
| June 20 | 3600 flies lay | 432,000 | eggs |
| June 30 | 216,000 flies lay | 25,920,000 | eggs |

*Expose some raw meat to flies. Then place it in a glass jar covered with cheesecloth or a fine wire screen, and watch the*



SOME INSECTS HAVE AN INCOMPLETE METAMORPHOSIS. WHERE WOULD YOU LOOK FOR THE NYMPHS OF GRASSHOPPERS, TERMITES, AND DRAGONFLIES?

*small white larvae complete their life cycle. Examine the raw meat daily to follow developments as much as possible.*

There are insects that have a complete and an incomplete *metamorphosis*. The word metamorphosis means a change. The monarch butterfly, the cecropia moth, and the flies undergo a complete metamorphosis; that is, there are four distinct stages in their development. The nymphs of the grasshoppers, termites, and dragonflies do not differ so decidedly from the adults, so they are said to have an incomplete metamorphosis. The life histories of insects form one of the most interesting studies in the division of science called biology.

Another great order of animals includes the snakes. Snakes are found in nearly all of the climates of the world; in deserts, in the tropics, and on high mountains. Some species spend most of their lives in trees, while others live in swamps and fresh-water lakes. A few species live in the sea. Those of you who live in large cities may find it necessary to visit a zoo or a natural history museum in order to see some of the different kinds of snakes. Those who live in the country or in smaller communities may know several kinds. Some snakes make very satisfactory pets for people who like them. Several species are, to be sure, poisonous, but many of the snakes are harmless and even helpful.

Many boys and girls are familiar with the *garter* or the *garden snake*. These are the most common snakes in the northeastern states, and a related species is found on the Pacific Coast. They are usually small and vary in color. They are always yellow or green with whitish stripes that run lengthwise down the snake's body.

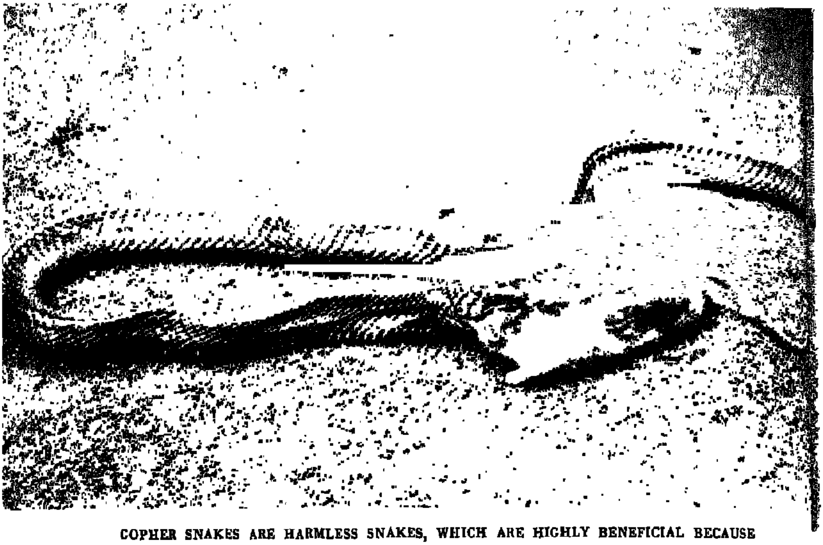
Garter snakes have a surprising method of reproduction. The mother snake does not lay eggs, as many snakes do, but produces from eleven to fifty living young.

The food of garter snakes consists of insects, small toads, and earthworms. These snakes are entirely harmless but, however, do not make good pets because of a rather unpleasant odor.

The *king snake* is sometimes called the *milk snake,* or the *spotted adder.* This snake received its name because it is sometimes seen around barns and milkhouses. Milk snakes are pale gray in color and covered with many brown or dark gray splotches. Unlike the garter snakes, milk snakes hatch from eggs. They vary in length from fourteen inches to six feet. King snakes may be safely handled and make good pets. They are beneficial reptiles because they kill rats, mice, and poisonous rattlesnakes and copperheads by constriction.

The *gopher* or *bull snakes* are the largest snakes in North America. They may reach a length of nine feet. You will understand that the western bull snakes are harmless when you know that these are the snakes that are commonly used by the "snake charmers" in the sideshows of circuses. Gopher snakes

MANY SNAKES ARE HATCHED FROM EGGS. SOME SPECIES, AS THE GARTER SNAKES, HAVE LIVING YOUNG.



COPHER SNAKES ARE HARMLESS SNAKES, WHICH ARE HIGHLY BENEFICIAL BECAUSE THEY DESTROY SMALL RODENTS, SUCH AS GOPHERS AND RATS.

hatch from eggs. They kill rats, gophers, mice, ground squirrels, pocket gophers, and rabbits by constriction. These small rodents are their favorite food. It is very evident that gopher snakes are entitled to protection because of their help in controlling such pests.

The commonest wild mammals we have around us are the rodents. Rodents are usually small animals that have front teeth adapted for gnawing. They belong to a class of animals known as mammals. Mammals are the most highly developed of the many kinds of animals. They are warm-blooded creatures, with hair, an intricate nervous system, and mammary glands (milk glands) with which the mothers nourish their young. The last characteristic gives the name of mammals to the division of animal life to which man as well as a great variety of animals belong. Mammals vary in size from the tiny field mouse to the elephant. Some fly through the air. Bats are flying mammals. Others live in the water. Seals and whales are mammals that inhabit the oceans in some areas. Most of the mammals live on land and walk on four legs.

Rats and mice are among the most destructive of the rodents. Rabbits, squirrels, and beavers are other members of this order that have strong front teeth fitted for gnawing.

The brown rat, also called the wharf rat, gray rat, and Norway rat, is our worst enemy in the animal world if we except insects. This rat was first reported in the United States in 1775, having arrived on some ship as a stowaway. As people migrated westward, the rats migrated also. Rats are among the most prolific of mammals. One female may produce six or ten litters a year and each litter averages ten young rats. In three years one pair of rats could have many thousand descendants.

Because rats are not limited in what they eat, they live almost anywhere—in open fields, along river banks, and on piers, but their favorite dwelling place is in buildings.

The magazine *Hygeia* estimated that in the United States alone, rats destroy $500,000,000 worth of crops and property each year. Rats do much more damage than mice. Grain, poultry, and stored food of all kinds are eaten by these hungry rodents. Many fires are traced to their gnawing habits. What safety precautions could be taken to prevent such fires?

You may have read of the Black Death which caused the death of twenty-five million people in Europe during the fourteenth century. More recently, in 1907, two million people died in India of this plague, now called bubonic plague. Rats and the fleas that live on them are the carriers of the germ of the bubonic plague.

Besides the brown or Norway rats there are other kinds to be found in the United States. The wood rat, or pack rat, is found on the Pacific Coast and in the southern states. Their nests, which are usually made in waste places, may be a foot high and are fashioned from small sticks. The cotton rat of the South is a vicious and destructive rodert.

White rats are very often used as laboratory animals for various kinds of experiments. Many of the feeding experiments that have added much to our knowledge of the use of foods have been done with white rats. *Make a list of things you can find about white rats that make them suitable animals for laboratory use? Go back over the paragraphs that you have just read and see if you can answer this question.*

Some members of the class may be interested to make some reports upon scientific experiments that have used rats as experimental animals. Where would you look to find descriptions of such experiments?

Mice are the smallest of the rodents. Like the rats, they multiply rapidly. Each female may have six or more litters in a year with an average of six young to a litter. In one year one pair of mice may increase to four hundred and thirty individuals, and in two years they may have many thousand descendants.

House mice, which originated in India, destroy food, clothing, and furniture. Meadow mice or field mice, called voles in England, destroy grass, grain, fruit, vegetables, and orchard trees. Sometimes mice are so numerous in a field that people speak of a plague of mice. It is estimated that there may be twelve thousand of them on one acre of ground. In winter, when food is scarce, these mice burrow under the snow and gnaw the bark from the bases of orchard and other trees. This may kill the trees.

In the southern states there is a species of mice called harvest, rice, field, or grasshopper mice. As the last name suggests, grasshoppers are destroyed by these mice. Thus, we have an example of a mouse which is sometimes, at least, beneficial.

Most of you know the cottontail, the most common rabbit in the United States. This rodent derives its name from the fact that the underside of its tail is white. There are several litters of young each year with from three to seven small rabbits in each litter. Cottontails eat growing plants and they are usually able to secure sufficient food. They in turn are eaten by foxes, coyotes, hawks, owls, and man. Rabbits do much damage to young orchards and growing gardens.

THE COTTONTAIL IS FOUND THROUGHOUT MUCH OF THE MIDDLE WEST AND MANY OF THE EASTERN STATES.

The black-tailed jack rabbit of the western plains is much larger than the cottontail, reaching a length sometimes of twenty-eight inches. The jack rabbits may ruin alfalfa fields in summer and stacked hay in winter. When the jack rabbits become too destructive, "drives" are held. As many as 20,000 of these rodents have been killed during one "drive."

*Red squirrels* are one of several kinds of squirrels. They nest in the cavities of trees and live largely on nuts and the seeds which they find in pine cones. Can you explain why red squirrels prefer to live in evergreen forests?

Red squirrels have spread into cities and are common inhabitants of parks and yards where there are trees. They have the disagreeable habit of robbing birds' nests, and for this reason they cannot be allowed to become too numerous.

Rodents are the most destructive of all the mammals. It is fortunate they have so many natural enemies that aid in their control. We should learn what the various enemies of the different kinds of rodents are and encourage some of them to live about our homes and buildings. This is especially true in view of the fact that rodents increase so rapidly.

Several mammals are valuable pets. Some people have white rats, rabbits, and guinea pigs (which are also rodents) for pets. Where there is more space, ponies and horses, belonging to the order of hoofed mammals, are useful and pleasure-giving pets. City people, as well as country dwellers, keep dogs and cats.

People who have a cat as a pet will not agree, perhaps, with the results of a study that was made by the Massachusetts State Board of Agriculture. The report showed that cats are the least useful of all the mammalian pets. This is because cats are frequently destroyers of birds, the natural enemies of harmful insects. What measures should be taken in your community to cut down the killing of birds by cats?

Whether our pets are goldfish, canaries, white rats, dogs, cats, or ponies, we have a responsibility to see that they are supplied with life's necessities—food, fresh water, air, and shelter. We must keep their cages or quarters clean and sanitary, and protect them from extreme changes in temperature. When we go away on a vacation trip, we must make arrangement for their care, always remembering that many animals have been held in captivity for such a long time they can no longer care for themselves.

If you will go back over the descriptions of different kinds of animals in the last few pages you will observe that the many differences in the orders and species of animals seem to make each animal better fitted to live in the kind of environment in which it is most commonly found. Students of animal life have a particular word for this. They speak of this being fitted to live in a particular environment as *adaptation,* or sometimes as *adaptation to environment.*

Some adaptations are of advantage in food getting. Recall the beak of the woodpecker, the bill of the humming bird, the chisel-like teeth of the squirrel and other rodents, and the long coiled tongue of the sphinx moth.

Other adaptations serve as protection from enemies. Think of the various colorings of snakes in this connection. Grass snakes are green, desert snakes are marked to fit into the desert landscape. Do you recall the colors of nesting birds and how these often fit into the surroundings in which the nests are found. Do brightly colored male birds often sit on the nest? Can you find other adaptations for protection in animals other than coloring?

If you will reread a part of Unit Three you will find a description of the adaptations of different kinds of animals for getting oxygen, gills in fishes and lungs in common land animals. Do you see why the insects, having no inside skeletons, need a special adaptation in the form of breathing tubes for getting oxygen from the air?

There are many other kinds of adaptations. In some cases there are peculiarities that do not seem to us to be advantages. These are often difficult to explain. You will be able to learn much more about animal life if you will be continually on the alert to see the ways in which animals have become adapted to the conditions under which they live.

Plants as well as animals become adapted to peculiar conditions after many generations. In the pages that follow, see how many interesting plant adaptations you can find. Look for these as you actually observe plants out of doors.

### 4. What kinds of plant life are found about us?

If, with pencil and paper, we were to take a walk around a block near our school, we could probably make a long list of plants seen. All of the plants we would see would have had the correct conditions of temperature, moisture, food supply, and air if they have grown to be large and strong. Many plants seen on our walk will be familiar to us.

The first plants to attract our attention would be the trees, because they are the tallest plants that we commonly find. Their roots extend far into the soil in order to absorb the necessary water and soil minerals. Their leaves secure the carbon dioxide that enters into their food from the air.

If we repeat our walk during different seasons of the year, we may notice that some of the trees bear at times vividly colored leaves, and during a part of the year, having shed their leaves, are entirely without foliage. The maples, oaks, willows, elms, and sycamores are examples of this class of trees and are called *deciduous* trees. Many of our fruit and nut trees are deciduous.

*Collect, press, and mount the leaves from twelve or more deciduous trees. Label each kind correctly.*

We may also see some evergreen or *nondeciduous* trees. These trees are called evergreen because they do not shed their leaves entirely at any time during the year. The most common of the nondeciduous trees are those which bear their seeds in cones. The pines, spruces, and firs are some of these.

The cone-bearing trees, called *conifers*, are especially fine on the Pacific Coast. In the states of Washington, Oregon, and California there are large forests of yellow pine, Douglas fir, sugar pine, red and white fir, and cedars. The conifers have also reached a fine state of development in Maine. As recently as 1925 nearly three fourths of the area of this state was in forests. Visitors to the Maine woods are familiar with the different species or kinds of spruce, fir, pine, cedar, and hemlock that grow there.

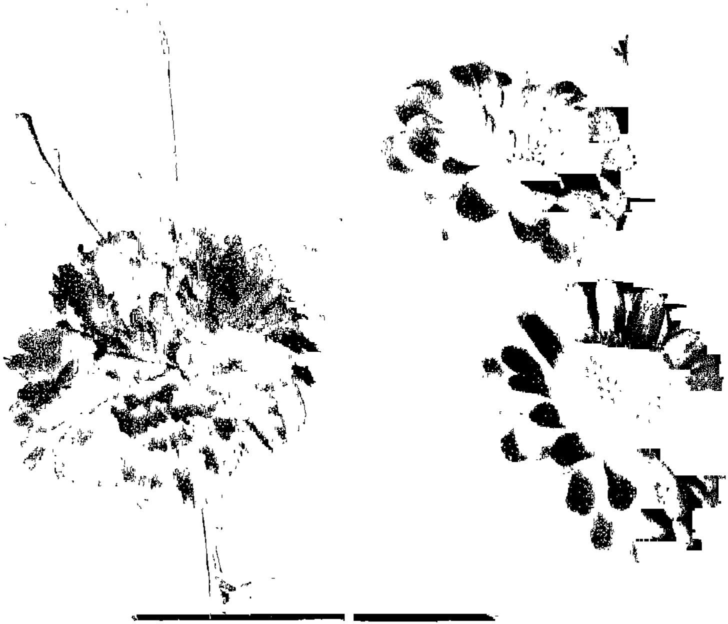
Boys and girls who live in California may find an example of the redwood family on their walk. California is now the only home of this family of coniferous trees in the United

States. The coast redwoods grow for a length of nearly four hundred miles along the California coast. These beautiful trees form dense forests. In the Sierra Nevada Mountains the big trees, *Sequoia gigantea*, are found. The General Sherman tree shown at the right is a famous sequoia in the Sequoia National Park.

*Collect the cones from as many kinds of coniferous trees as you can. Label each kind.*

In Florida and California we can find broad-leaved evergreens. The live oaks grow in both states. In California the eucalypti, acacias, and pepper trees are green throughout the year.

At certain seasons of the year and in many localities our attention is attracted by flowering plants. Some of them are wild flowers, and others, garden flowers. It should be kept in mind that almost all cultivated flowers were once found growing wild, and that someone admired them enough to domesticate them. Several of the cultivated plants closely

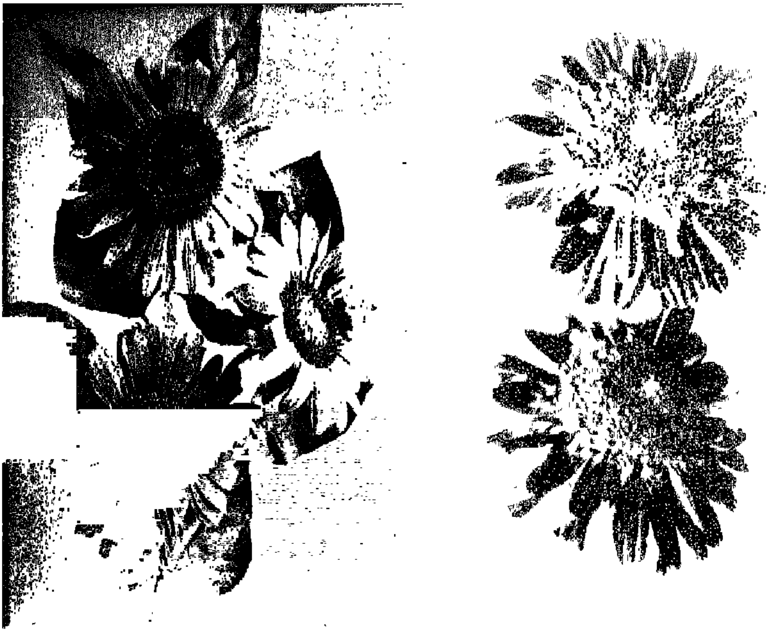


MARIGOLD ZINNIA

THESE FLOWERS ARE MEMBERS OF THE COMPOSITAE FAMILY.

resemble their wild cousins. Some are "created" by breeding and their ancestors only were wild. The wild iris, sweetpea, trillium, columbine, and larkspur bear unmistakable kinship to the cultivated flowers of the same name.

Flowers are classed as *annuals*, *biennials*, and *perennials*. Annuals must be replanted or resown each year. Some familiar annuals are asters, nasturtiums, zinnias, marigolds, scabiosas, and sweetpeas. Biennials are plants which do not produce flowers and seeds until the second year of their growth. There are fewer examples of biennials than of annuals and perennials. However, the stately hollyhocks, foxgloves, and pansies are biennials that are generally admired. Perennials may live for several years and need not be replanted each season. Chrysanthemums, violets, Shasta daisies, and peonies are perennials common in yards and gardens.



SUNFLOWER CHRYSANTHEMUM

WHAT CHARACTERISTICS DO THESE PLANTS HAVE IN COMMON?

When we consider our garden flowers, we find that those that are common belong to a very few of the many plant families. Plants which have the same characteristics and general structure are said to belong to the same family. Often the structure of the flower and the seed-bearing parts determines the family. *Study the flowers in the illustration and decide why all of them belong to the same family.*

The lily family includes many of our most beautiful flowers. These plants usually have leaves with veins that run generally parallel to the midrib. Many of the earliest blooming perennial flowers in our gardens, such as tulips, narcissi, and crocuses, belong to the lily family or to closely related groups. Other representatives of the lily family are Watsonias, hyacinths, lilies of the valley, and all lilies, such as the beautiful Easter lily, and the golden-banded lily of Japan.

Another large and showy family *(Compositae)* has flowers in a head. Annuals, such as marigolds, gaillardias, zinnias, and the perennials, such as African daisies, Shasta daisies, and chrysanthemums, belong to this family. Sunflowers, dandelions, and goldenrod are also composites.

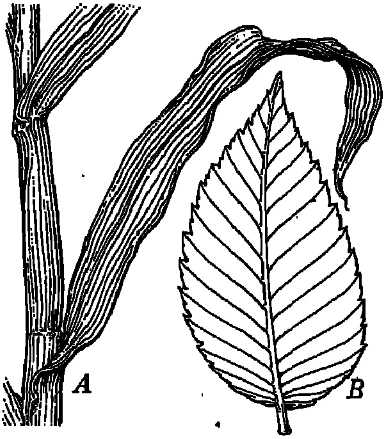
The sweetpeas, hyacinth beans, and scarlet-runner, as well as garden peas and beans, are *legumes.* These plants have pealike flowers and seeds most often in pods.

The tall blue delphinium, a perennial plant, and the smaller annual larkspur, belong to the *crowfoot* family. This family also includes the columbine grown in many colors in our gardens.

The poppy family includes many lovely annual flowering plants. The Oriental, Iceland, Shirley, and California poppies are seen in a variety of colors and markings.

There are, of course, other garden flowers that you have seen and admired. *Make a list of them and use some reference book that your teacher may suggest in order to learn the family to which they belong, and whether they are annuals, biennials, or perennials. Do not forget the rose family and its many members.*

In many instances we pass areas that contain cultivated plants that are grown for the food supply of man and his domesticated animals. Some of the grasses and vegetables that are grown for food will be discussed in Unit Ten.



THE GRASS AND LILY FAMILIES HAVE LEAVES WITH VEINS WHICH RUN PARALLEL TO THE MID-RIB. USUALLY SMALL VEINS RUN FROM THE MID-RIB.

There are myriads of plants around us that we do not see. The *bacteria* are the smallest living plants that are visible only with the aid of a microscope.

There are several kinds of soil bacteria of great importance to us. One type of bacteria causes the decomposition of materials used as fertilizers that are spread on fields and gardens. Another kind is found in the nodules (see page 134), small swellings, which are found on the roots of clovers, alfalfas, beans, and other members of the legume family. These bacteria are able to take nitrogen from the air and combine it with other substances in the soil, producing the nitrogen-rich compounds. Our cultivated plants, as well as many wild plants, grow luxuriantly because of the activities of the bacteria in the soil.

### 5. What are some undesirable plants?

In the last section we discussed some desirable trees and flowers that are helpful plant neighbors. In this problem we shall consider some of the weeds and fleshy fungi, which are always undesirable neighbors because they use the food, soil, and space needed by cultivated plants.

Weeds may be defined as plants that grow where they are not wanted. Under natural conditions one plant is just as much a weed as another. In any given space there is a limit to the amount of those things needed for life. On an acre of ground in a particular climate just so much water is available in a year. This limits the number of plants that can grow in this space and the number of animals that can be supported by these plants. Even the needed sunlight can reach just so many plants in a given space. If many plants grow and the ground is shaded, smaller plants coming up from below receive no light and do not thrive.

Many more seeds are produced than live and grow into full-sized plants in the space that is available. Some of the young seedlings must die. We call this constant struggle to live, a *struggle for existence.* In this struggle only the strongest, or those best fitted to the environment by adaptations, live. Scientists call this the *survival of the fittest.*

If both dandelion seeds and grass seeds become distributed over a lawn, only those will live that can be fed by the available water supply and the mineral compounds from the soil. Some will not get enough sunshine because they will be shaded in the crowding. If the summer is hot and dry and the dandelions are better adapted to going down deeper into the soil for water than the grass, many dandelions are likely to survive and probably fewer grass plants. If the lawn is mowed, the grass plants may suffer from too much cutting. The low flat rosettes of the dandelions escape much of the cutting. Again the adaptation favors the dandelion.

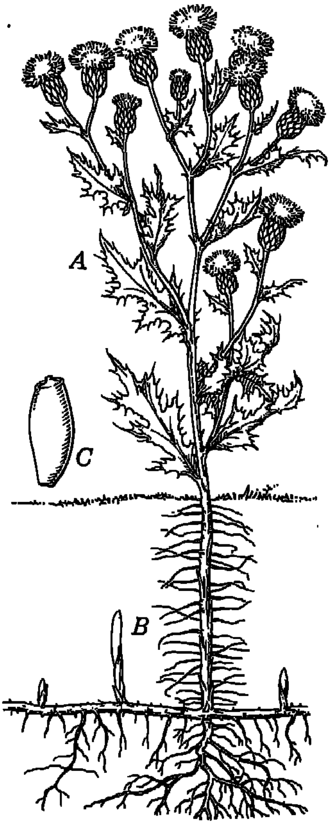
When human beings try to raise plants for their own purposes, any others that use up the available supply of water or of fertilizer interfere with the wanted ones. We call these unwanted plants weeds and try to remove them, discourage their growth, or prevent the ground from becoming seeded with them. If we want grass in the lawn, the dandelions are weeds. If we wish to grow dandelions for use in place of spinach as greens, the grass becomes the weed.

There are three groups of weeds: annuals, biennials, and perennials. Annual weeds live but one year. They produce seed but once and then die down entirely, root and all. Biennials live for two years, producing seed the second summer. Perennials live three years or more. Some perennials are spread not only by seed but also by underground roots or stems.

Black mustard is a troublesome annual found in many places. Like the wild radish, also an annual, mustard produces large quantities of seed. At times, both weeds nearly crowd out cultivated crops.

Dandelion, plantain, shepherd's purse, oxalis, Bermuda grass, bindweed or wild morning glory, and the Canada thistle are all perennial weeds. Canada thistle is a great pest in the corn states. The plant produces great quantities of seed and also spreads from an underground stem that is sometimes called a rootstock.

Smooth dock and sour dock are perennial weeds which grow in waste places, meadows, and pastures. Both plants have long, fleshy taproots and produce an abundance of seed.



THE CANADA THISTLE IS HARD TO DESTROY. (A) REPRESENTS A MATURE PLANT; (B) ROOTSTOCK WITH STEM AND SPROUTS; AND (C) SEED.

Milkweed is frequently found in corn fields, small grain fields, waste lots, and along roadsides. This plant, which is associated with the monarch butterfly, has fleshy, creeping rootstocks. Each plant produces several clusters of whitish flowers, some of which develop into the large green pods that are filled with seeds. How are milkweed seeds scattered?

There are fewer biennial weeds than annuals or perennials. Wild carrot is a common biennial weed in the eastern states.

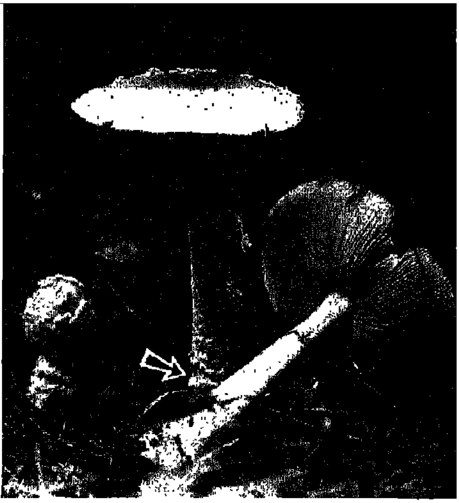
Curled thistle, purple star thistle, blueweed, and burdock are also biennials. In a list of fifty of the worst weeds in the United States, compiled by the United States Department of Agriculture, only two are biennials.

In the following table, you will find the names of some of the most troublesome annuals, biennials, and perennials that occur in the United States. How many of these weed pests can you identify?

| Annuals | Biennials | Perennials |
|---|---|---|
| buffalo bur | wild carrot | Bermuda grass |
| chickweed | bull thistle | bindweed |
| cocklebur | | bracken or brake |
| foxtail | | oxeye daisy |
| jimson weed | | dandelion |
| lamb's quarter | | curly dock |
| prickly lettuce | | horse nettle |
| wild mustard | | Johnson grass |
| puncture vine | | peppergrass |
| ragweed | | plantain |
| Russian thistle | | quack grass |
| | | sheep sorrel |
| | | sow thistle |

You may be interested in making a weed collection. *Collect, press, and mount specimens of twenty of the worst weed pests in your locality. Label them carefully, noting whether they are annuals, biennials, or perennials.*

Another group of undesirable plants that we may find during certain seasons of the year are the poisonous *fungi* that we call toadstools. Fungi are different from the familiar green plants because they never have the green coloring matter that is called *chlorophyll*. For this reason fungi are never green. They are usually white, and sometimes yellow or brown, and even red, but no one has ever seen a green fungus.



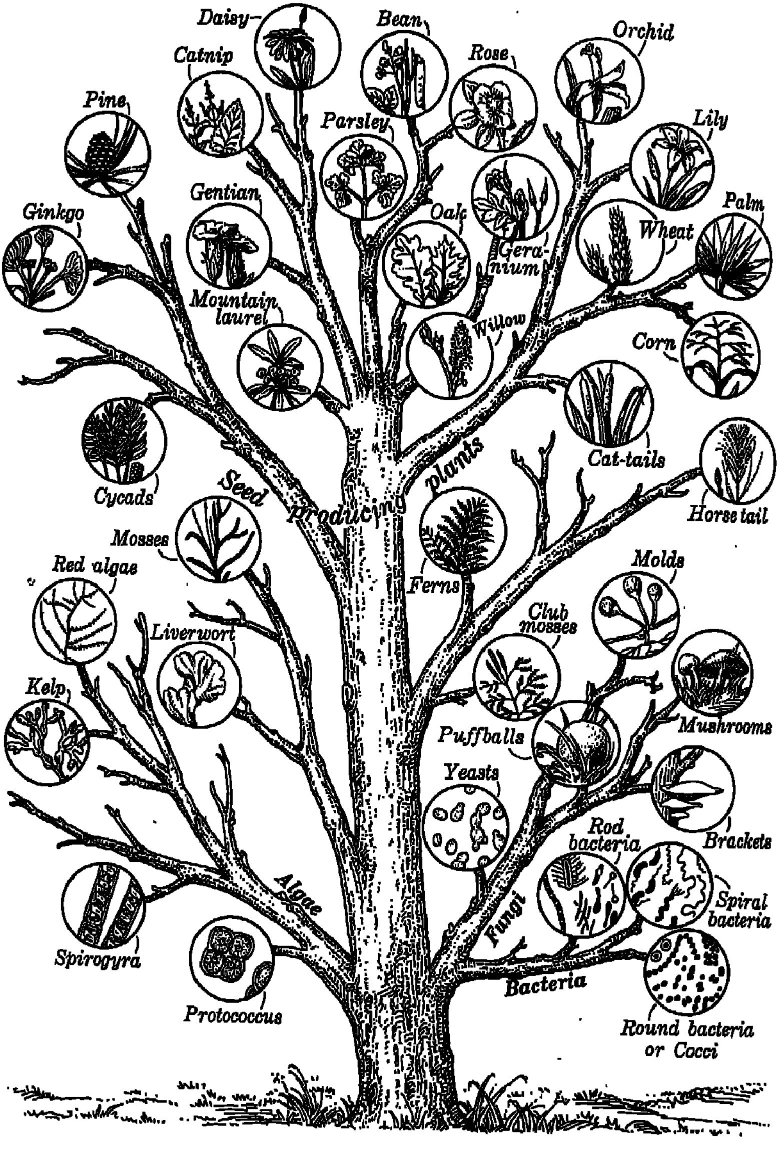
MANY PEOPLE HAVE DIED FROM THE EFFECTS OF EATING POISONOUS TOADSTOOLS.

The fungi that are prized for food by many people are usually referred to as mushrooms. It is unfortunate that it is so easy to mistake some of the poisonous toadstools for the edible fungi. Some of the most poisonous fungi are provided with a "death cup" which is shown in the picture. Any plant that has this so-called "death cup" is plainly labeled as being dangerous. There are, however, other poisonous species equally dangerous that are not so plainly labeled. A wise person will not gather any of these plants unless he is very certain they are of a variety that can be safely eaten.

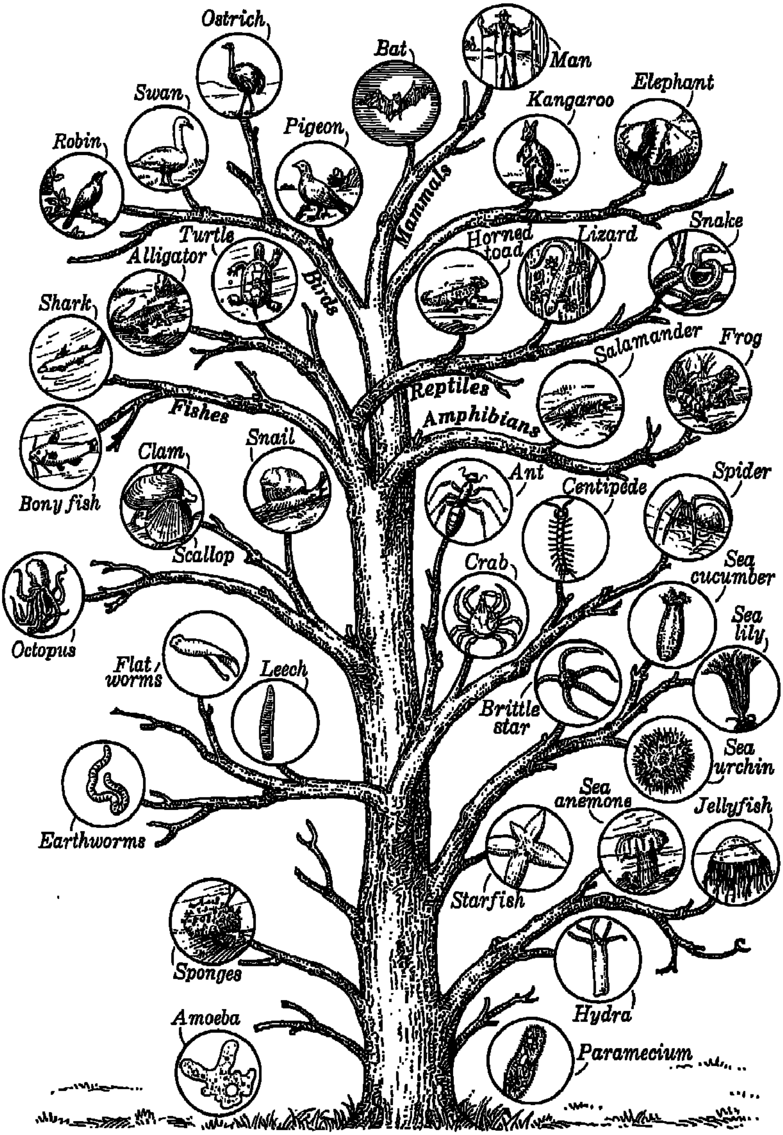
If one must have mushrooms, mushroom spawn can be purchased in some seed stores, and planted so that the plants may be safely eaten. Canned mushrooms are usually free from poisonous species.

### 6. How do present-day plants and animals differ from those of previous times?

The different kinds of plants and animals noted in this unit were not always found upon the earth. New forms of life developed gradually and are still making their appearance. From such evidence as we have, we conclude that the one-celled animals, such as the paramecia, and the simple plants, like the algae, were the first kinds of life to appear.



WITH HOW MANY PLANTS OF THE TREE OF PLANT LIFE ARE YOU FAMILIAR?



WITH WHICH ANIMALS OF THE TREE OF ANIMAL LIFE ARE YOU FAMILIAR?

REPTILES RULED THE EARTH MILLIONS OF YEARS AGO. SCIENTISTS BELIEVE BIRDS ARE DESCENDED FROM PREHISTORIC FLYING LIZARDS.

Millions of years ago, so long ago it is difficult to imagine, the only life that existed on our earth lived in the water.

Plants began to live and grow out of the water and on the land long before the animals did. For countless ages the different forms of animal life lived in the water. These were the kinds of animals that we call invertebrate animals; that is, they had no bony skeletons. At this far distant time, the oceans are supposed to have contained fresh water, just as the lakes and rivers do today. The fishes were the first animals to have a skeleton. One species of fish was called a lung fish. It obtained air through one lung and is thought to have been the first of all lung-breathing animals that have since developed.

Some of the reptiles lived in the water and some lived on land, just as they do today. One species of prehistoric reptile flew through the air. Many people think that birds descended from these flying reptiles.

The seed-bearing plants were the last forms of plant life to develop, and the mammals were the last of the many branches of the animal kingdom to appear. Study the preceding trees of life to learn which are the newest plants and animals, and which were the first to develop on this planet.

### THINGS TO DO

1. Make a collection of twenty-five wild flowers from your locality. Press, and mount them in a scrapbook, naming each kind correctly.
2. Make a feeding table for seed-eating birds that are around your home in winter.
3. Make a birdhouse for wrens, bluebirds, or small woodpeckers. Find a suitable place for placing the house and put it up. If you do not have a lawn or garden, see if you can get permission to put up birdhouses on the school grounds or in a near-by park.
4. Collect "oak apples" and galls from different plants. Place the galls in tightly covered glass jars to learn what kinds of insects caused the galls.
5. Write to the Zoology Department of your State College or State University for a list of the different species of snakes that are found in your state.
6. Write to the Zoology Department of your State College or State University for a check list of birds that have been observed in your state. Your state conservation department at the state capitol may be able to furnish such a check list.
7. Make a collection of toadstools and mushrooms. Dry the plants by placing them above a warm radiator, or near a stove. Ask your teacher for help in labeling them.
8. Find a vacant lot near the school where members of the class can secure permission to make a weed survey. How many different kinds of weeds grow on this lot? Lay off an area five feet square. Mark this into one-foot squares with strings staked off across it like a checkerboard. How many plants grow in this small area? How many different kinds? Which plants grow in greatest

numbers? What special adaptations have these plants that might explain why they are found in such numbers?

9. Plant the seeds of three kinds of annual flowering plants in window boxes or in a garden. Keep a record of how many days were required for the seeds to become flowering plants.
10. Make a kodak record of the appearances of some different trees in your locality during the summer and winter months. Let the pictures tell why oaks, maples, elms, and fruit trees are deciduous trees, and pines, cedars, firs, and spruces are nondeciduous trees. Exhibit the pictures on the class bulletin board.

### SOME THINGS TO REMEMBER

1. Living things were not always present upon our earth.
2. Many kinds of insects spend all, or parts of their lives in the soil.
3. Every kind of living thing requires food, air, some heat, and water.
4. Temperature is an important factor in the lives of plants and animals.
5. Environment is another name for our surroundings.
6. Aquatic plants and animals live in the water.
7. The fish is a vertebrate animal.
8. Frogs belong to a class of animals called Amphibia.
9. An order is a division of the animal kingdom which contains several related families.
10. Most of the song birds belong to the order of perching birds called Passeres.
11. Birds are classed as residents, summer residents, winter residents, and transients, depending upon how long they remain in a locality.
12. Birds usually build their homes near their food supply.
13. Many birds protect their nests by a method called *concealment by abandonment.*

14. Birds are the chief enemies of our many insect pests.
15. Adult insects have three body divisions: head, thorax, and abdomen.
16. Many species of insects pass through four distinct stages in their life cycles: egg, larva, pupa, and adult.
17. Many insects escape their enemies because they have protective coloring.
18. After many generations, a particular species of plants or of animals becomes adapted for living in its particular environment. This is called adaptation to environment.
19. Snakes are reptiles found in warm climates of the world.
20. Many snakes are helpful because they destroy rodents.
21. Rodents are gnawing mammals.
22. The rat is the most destructive animal in the United States if we except the insects.
23. Deciduous trees shed their leaves in the autumn.
24. Nondeciduous trees are evergreen.
25. Conifers are trees which produce their seeds in cones.
26. Annual flowers must be replanted each year.
27. Biennial plants do not produce flowers and seeds until their second year.
28. Perennial plants sometimes live for many years.
29. Microscopic plants called bacteria live in the soil.
30. In any given space the things needed for life are limited. Only a part of the plants and animals that begin life can be supported in a limited space.
31. Only the strongest or the best adapted individuals survive in any particular local environment. This is called *the survival of the fittest.*
32. Weeds are plants growing where people do not want them to grow.
33. Toadstools, which are never green in color, are poisonous fungi.
34. The different kinds of plant and animal life developed gradually over a long period of years.

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Patch, Edith M. *Bird Stories.* Little, Brown & Company.

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Stevens, G. A. *Garden Flowers in Color.* The Macmillan Company.

Stephenson, Mary Bowen. *The World of Animals.* Follett Publishing Company.

## OTHER THINGS TO READ

*Farmers' Bulletins,* United States Department of Agriculture:
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  No. 1456F. *Homes for Birds.*
  No. 1459. *Insect Enemies of the Flower Garden.*
  No. 1569. *Earthworms as Pests and Otherwise.*

Circular N. 363—*The Migrations of North American Birds.* United States Department of Agriculture

*National Geographic Magazines:*
  January, 1928. Nelson, E. W. *Bird-Banding, The Telltale of Migratory Flight.*
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  May, 1937. Williams, C. B. *Butterfly Travelers.*

# UNIT SIX

## UNIT SIX

# We Turn With the Earth

### WHAT THIS UNIT IS ABOUT

The present age has been called an age of speed. Airplanes, automobiles, and trains are designed for the greatest possible speed. Huge air liners travel across the United States at a rate of two hundred miles or more per hour. Racing automobiles have a possible speed of over three hundred miles an hour. New streamlined trains cross the continent at an hourly rate of eighty or eighty-five miles.

Sitting in your seats at school, or sleeping soundly in your beds, you are traveling through space at a speed that no machine can ever equal. The earth turns so evenly and so smoothly it is hard to believe that, due to the rotation of the earth through space, we who live on its surface are traveling at a speed of nearly a thousand miles per hour. People who live near the equator cover a distance of about twenty-five thousand miles every day. If you live in the latitude of New York, you are traveling a little slower, at the rate of about seven hundred and fifty miles an hour.

What is the force which keeps this great merry-go-round, the earth, in its path as it turns through space? Why don't we, who live on its surface, go hurling into space? What are some of the results of the *rotation* of the earth? What results from the *revolution* of the earth? You should be able to answer these questions, and many more, when you have completed the study of this unit.

# We Turn With the Earth

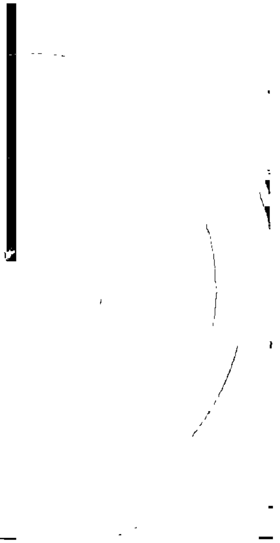
## UNIT PROBLEMS

1. What proof have we that the earth rotates?
2. What holds us to the earth?
3. Why do we have four seasons?
4. What well-known heavenly body turns with the earth?
5. How has the moon influenced the division of the year into twelve months?
6. What causes a total eclipse of the sun?
7. What causes a total eclipse of the moon?
8. How is standard time determined?
9. How can we locate places on the earth's surface?

### 1. What proof have we that the earth rotates?

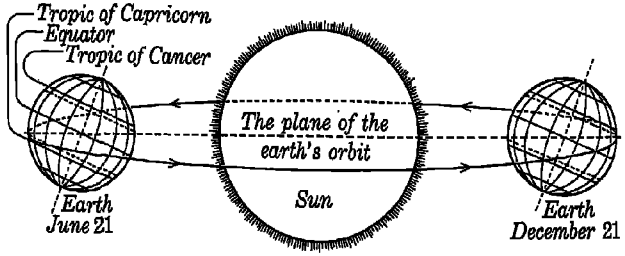
We are familiar with the spinning or rotating of a top. We may think of the earth as a giant top, which is always in motion and never still. The earth is a large globe, somewhat flattened at the poles. It has a diameter of nearly 8000 miles, and its circumference at the equator is about 25,000 miles. For many centuries people believed that the earth was flat like a plate, and that it floated on water. At about the time that Columbus made his famous voyage, which resulted in the discovery of America, more people began to accept the belief that the earth is round, although a few scholars believed it centuries before.

In those early days there were other beliefs that had to be overcome before people could accept the fact that the earth rotates. One of them was that the earth stands still, and that the sun rotates around the earth. A man born in Poland, known as Copernicus, first expressed the belief that the sun, and not the earth, is the center of the solar system. This belief, which was contrary to religious ideas of the time, was accepted by Galileo, the Italian scientist. Galileo's belief in Copernicus' theory caused him to be thrown into prison where he became blind and finally died.

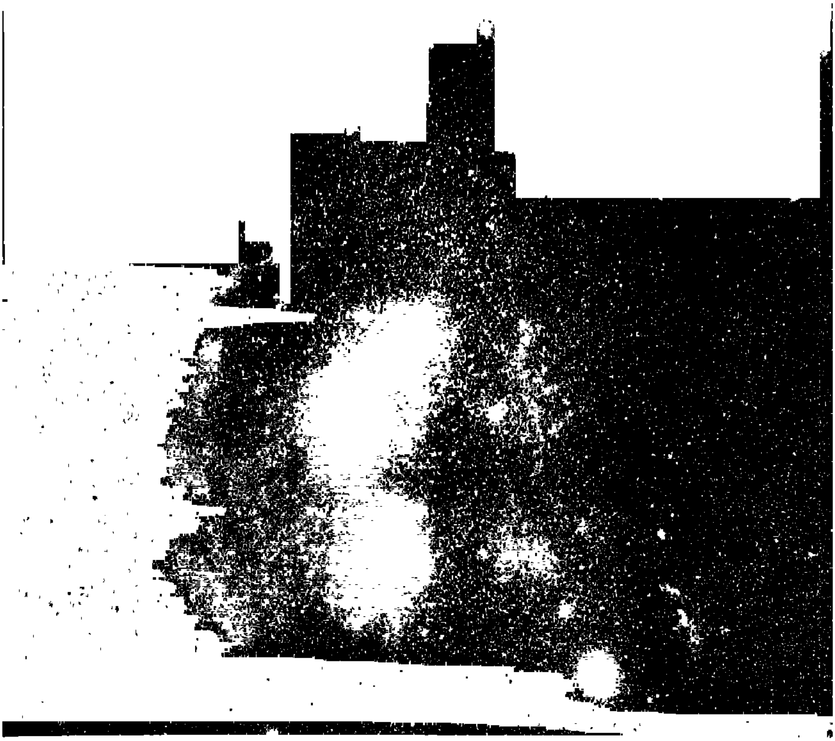


A PHOTOGRAPHIC FILM EXPOSED FOR ABOUT 2 HOURS SHOWS THE APPARENT TRAILS OF THE STARS.

It is true that the sun seems to move around the earth. We say that the sun rises in the east and sets in the west. As autumn approaches people frequently remark that the sun is moving farther south. What actually happens is that the earth turns or spins upon its axis from west to east (a motion opposite to those of the hands of a clock) once every twenty-three hours, fifty-six minutes, and four and nine-hundredths seconds. We most often say that it turns, or rotates, once in



AS THE EARTH REVOLVES AROUND THE SUN, IT SPINS ON ITS AXIS, WHICH HAS AN INCLINATION OF 23½ DEGREES.



ORION RISES EARLY IN THE EASTERN SKY DURING THE WINTER MONTHS.

twenty-four hours. The earth's axis is an imaginary line passing through the center from pole to pole. This axis is inclined, or tipped, 23½ degrees from the perpendicular. See the diagram on the opposite page. If the earth were not tipped upon its axis, conditions upon our globe would be very different from what they are.

How do we know that the earth rotates? Observations of conditions over the earth have furnished one of the proofs of the earth's rotation. As people traveled about, they observed that day and night are a common, daily occurrence. If the earth did not rotate upon its axis, one half of its surface would have continuous day, and the other half, continuous night. The regular alternation of day and night is one of the accepted proofs that the earth rotates.

We do not need to travel far to make another type of observation which proves that the earth is constantly rotating. If we leave our homes early in the evening during the winter months, we shall see the Constellation of Orion in the eastern sky. When we return a few hours later, the three bright stars that outline the belt of the hunter will be found to have moved into the southeastern sky. This apparent movement of the stars is another proof that our earth rotates.

Experiment has also added to our acceptance of the idea that the earth rotates. Less than a century ago, a Frenchman named Jean Bernard Leon Foucault swung a pendulum from the dome of the Pantheon in Paris, and for the first time the rotation of the earth was demonstrated by an experiment.

If the pendulum, which is a brass sphere suspended by a steel wire, is started swinging at noon in a north and south direction, it will be observed to be swaying slightly from the northeast to the southwest by four o'clock in the afternoon. This indicates the distance that the earth has rotated through space in the four hours.

You may see a *Foucault Pendulum* in many science laboratories and museums. When a visitor enters the doors of the Griffith Observatory and Planetarium in Los Angeles, he immediately sees the Foucault Pendulum which swings in a pit of marble and glass. As the earth rotates, the floor of the marble pit turns with it, causing the floor to rotate beneath the pendulum. You may find similar ones in the planetaria of other large cities, such as New York, Chicago, and Philadelphia.

You can make a photographic record to show the earth's rotation. *If you have a small camera, open the diaphragm of the lens as wide as it will go and prop it up so that it points to the stars in the northern sky near Polaris. If you have no camera, your teacher may be able to show you how* *to make and use a pinhole camera. On a clear night when there is no moon, expose the film for two or three hours. When the film is developed and a print made, you will have a record of the earth's rotation. Why?*

Several results occur from the rotation of the earth. Among them may be listed the following: the alternation of day and night; the flattening of the earth at the poles; the apparent movement of the skies in the opposite direction to that of the earth's rotation.

## 2. What holds us to the earth?

As we turn with the earth at a speed of hundreds of miles per hour, we might fear we would fly off into space. When

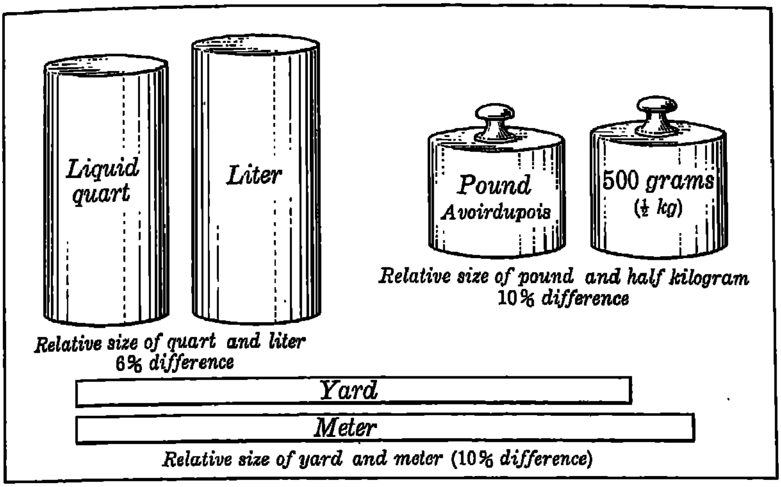
THE FOUCAULT PENDULUM SHOWS THE EARTH'S ROTATION.

a ball or any object is thrown into the air, it always falls to the earth. If the wind blows a man's hat from his head, it finally falls downward, and never upward. This is because of a force called gravity, or gravitational attraction.

*Gravity* is one of several unseen forces of great importance to us. Without the invisible force of gravity, the earth, moon, and other planets would fly off into space, and there would be many traffic accidents in the sky.

According to an old story, Isaac Newton was once sitting beneath an apple tree in England when an apple fell to the ground. Newton wondered if the force that pulled the apple to the earth was the same force that held the earth and the other planets in their *orbits,* or elliptical paths around the sun. In 1687 Newton gave the world the principle called the *universal law of gravitation.* The term gravity is frequently used to indicate the force of gravitation measured in some convenient term, such as weight. The pull of gravity exerted by a planet, moon, or star depends upon two factors. First, it depends upon the mass of the body. *Mass* refers to the amount of matter or material in a body. The second factor is the distance between two bodies. A body of large mass has a greater gravitational pull than one of small mass. Because the mass of the sun is so much larger than that of the earth, it is able to pull the earth toward it much as a large boy pulls a smaller boy toward him when they are engaged in a tug of war. If the larger boy continues to lengthen the rope which separates him from the smaller boy, he will reach a point where he cannot move his opponent. Smaller objects far away from the earth have no measurable gravitational pull upon it. As the moon is so close to the earth in comparison with other heavenly bodies, we see the results of its gravitational pull in the rise and fall of the water along the seacoasts.

The sun is able to pull the earth and the other planets to-

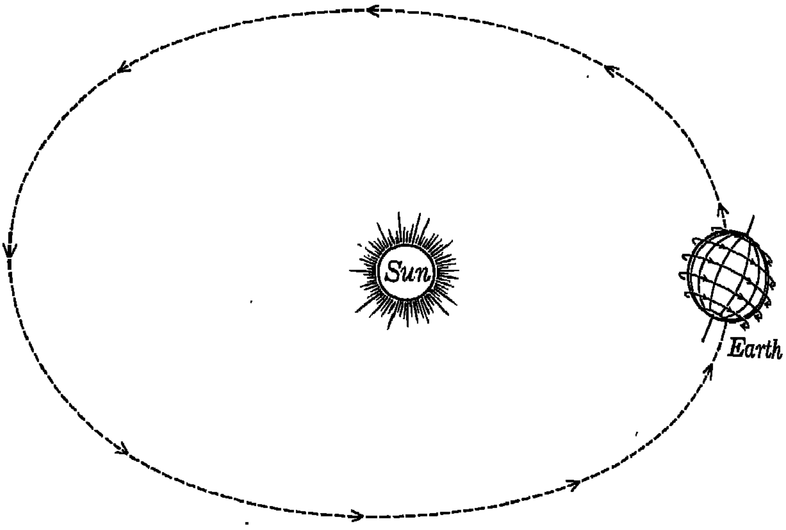

Liquid quart
Liter
Pound
Avoirdupois
500 grams
(½ kg)
Relative size of pound and half kilogram
10% difference
Relative size of quart and liter
6% difference
Yard
Meter
Relative size of yard and meter (10% difference)

THE METRIC SYSTEM IS USED THROUGHOUT THE WORLD WITH THE EXCEPTION OF THE UNITED STATES AND GREAT BRITAIN.

ward it and hold them in their orbits, because its mass is so much larger than that of the planets. Astronomers tell us that more than a million earths could be contained in the space which is occupied by the sun. The sun's *gravitational pull* is so enormous that it would draw the earth to it, if its gravitational force was not offset by another force which is called *centrifugal force.*

Bodies which move in circles exert a force called centrifugal force. This force acts to pull the bodies away from the center of the circle. Have you ever seen anyone swing a pail or kettle of water round and round without spilling the water? The water is kept in the container because of centrifugal force.

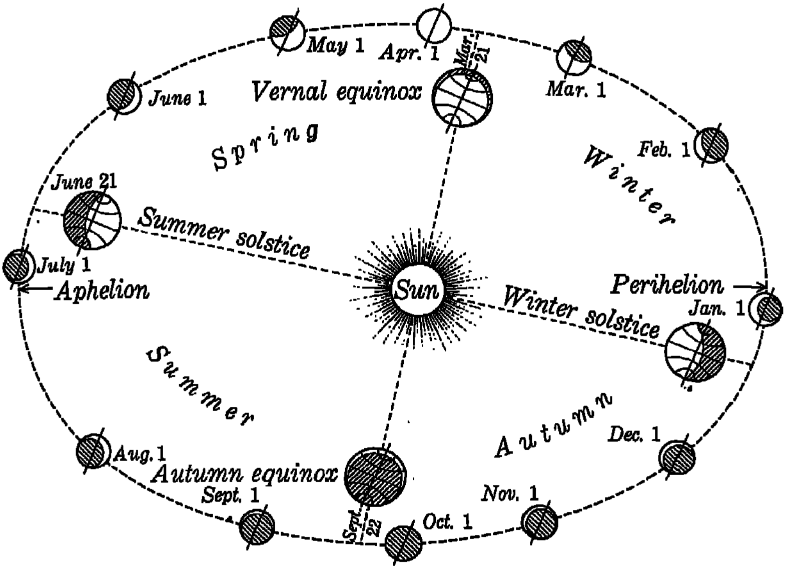
Because of centrifugal force a body that is set moving in a circle pulls away from the center and tends to fly off at a tangent to the circle. You have seen this when mud flies off a spinning automobile wheel. *Try the effect of this force for yourself. Tie a weight to the end of a stout cord five or six*



THE EARTH'S REVOLUTION IS THE BASIS FOR OUR CALENDAR YEAR.

*feet long. Find a clear space on the playground. Be sure no one is in the way. Hold the cord by the opposite end and swing the weight in a circle about you. You will be able to feel the pull on the cord. Let go of the end of the cord. What becomes of the weight? What would happen to a large piece of a mountain if in some way it could be broken off and the force of gravity released?*

The earth pulls on all objects on its surface just as the sun exerts a gravitational pull on the earth. The amount of the earth's gravitational pull upon an object is measured in pounds or grams. Weights of objects on the earth would be very different if the objects could be moved to the other planets. For example, a boy who weighs one hundred pounds on the earth would weigh about forty-four pounds on Mars. The same boy would weigh two hundred and fifty-six pounds on Jupiter. Larger planets have more gravitational pull than



AS THE EARTH REVOLVES AROUND THE SUN OUR SEASONAL CHANGES OCCUR.

the earth, and smaller bodies have less. We are thankful for the universal force of gravitation which holds all bodies to the earth, and keeps the planets and their moons in their accustomed places.

What use does your family grocer make of the force of gravity when you buy sugar, beans, or flour?

*Make a collection of weights used on balances in the school laboratories. Express what the marks on these weights mean in terms of gravity.*

### 3. Why do we have four seasons?

In the last section you learned that the turning of the earth on its axis causes night and day. The revolution of the earth about the sun causes a succession of periods of cold and heat which we call seasons. You are familiar with the terms: spring, summer, autumn, and winter.

After a long, cold winter people wait anxiously for the coming of spring. Then they plant their gardens and field crops, expecting that the warm summer days will bring about the development of a crop to be harvested in the fall or autumn. Why are people so confident that the seasons will follow each other in their accustomed order? If the earth had only the motion of rotation we should not have the four seasons with the changes of weather that they bring. As the earth rotates on its axis, it has another motion that is called *revolution.* As the earth revolves around the sun, we are sometimes nearer this great source of light and heat than we are at other times.

The fact that the earth revolves around the sun is only one of the causes for the passing of the seasons. We remember that the earth is inclined upon its axis at an angle of 23½ degrees. This causes the sun's rays to be nearly vertical in summer, and very slanting in winter. Although the earth is actually nearer to the sun in winter than it is in summer, we who live north of the equator receive less in the winter months of its radiant energy, which becomes heat and light. The seasons are not due to the weather, but to the earth's position as it revolves around the sun.

Spring does not actually begin until March 21, when the vernal or spring equinox occurs. The word equinox means equal days and equal nights. Many people think that the equinoxes cause storms over the earth's surface. This idea is only one of the many fallacies that have arisen concerning the apparent movements of the sun and the stars. On March 21 all places in the world have days and nights of equal length.

When the summer solstice occurs on June 21, the days in this hemisphere are much longer than the nights. The word solstice means the standing still of the sun. On this date the vertical rays of the sun are over the Tropic of Cancer, 23½ degrees north of the equator. At this time the vertical rays stop moving northward, and begin to move toward the equator. During the summer months the region of the North Pole is in almost continuous sunlight, and visitors to northern Alaska are in the land of the midnight sun. At the same time the antarctic zone about the South Pole is in darkness, as the sun's rays do not reach it at all.

The autumnal equinox occurs on or about September 23, and again the days and nights are of equal length. On this date the sun is directly over the equator, moving southward toward the Tropic of Capricorn. As the days of late fall arrive, the hours of darkness become longer than those of daylight in the northern hemisphere. In the southern hemisphere spring begins on the same date which marks the coming of autumn in the northern hemisphere.

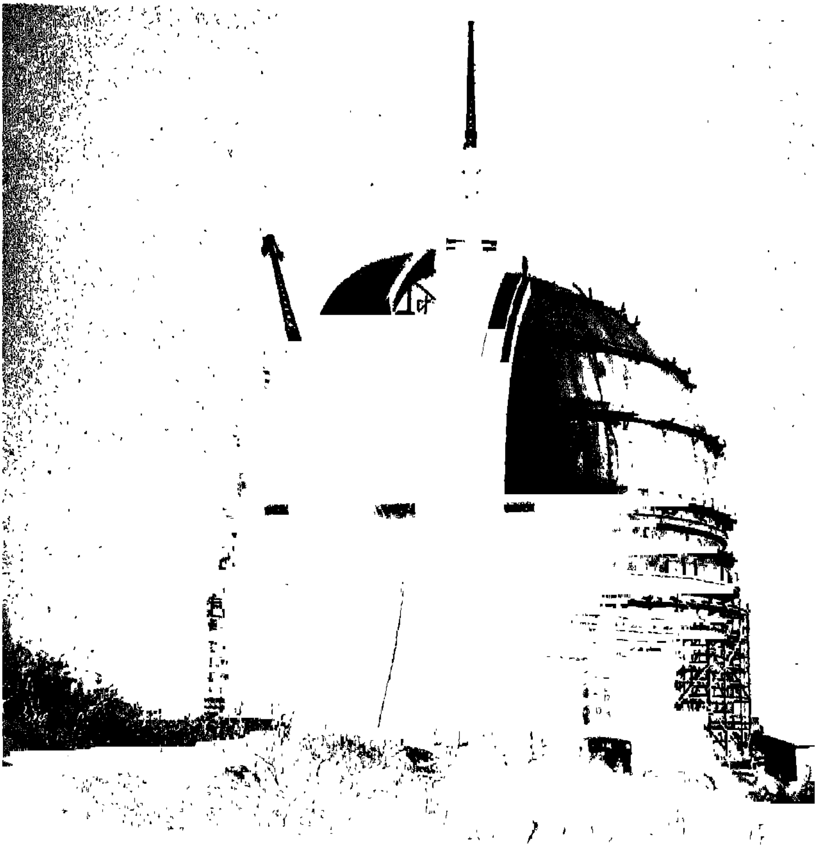
The winter solstice on December 21 brings the shortest day of the year to those of us who live in the northern hemisphere. The vertical rays of the sun are now directly over the Tropic of Capricorn. On this date summer begins in the southern hemisphere, and the region of the antarctic is lighted much as the Arctic Circle was lighted in June.

*Perform the following experiment to show that the sun's rays change from day to day at the same hour. Cut a small hole about a half inch in diameter in a piece of cardboard. Place the cardboard in the south window of a room, arranging it so that the sun's rays will pass through the opening and strike a piece of paper fastened on the floor or table. Draw the outline of the spot which strikes the paper. Repeat the procedure at the same time on succeeding days. Always write the date within each circle on the paper. In two or three weeks' time you will have a record which shows that the sun's rays strike the earth at different angles during dif-*

*ferent times of the year. This problem is difficult to carry through because moving the paper or cardboard will spoil the results.*

If the earth were like our sister planet Venus, practically upright on its axis, there would not be the four seasons. Venus' days and nights are always of equal length, and there are only two seasons, summer and winter. Venus rotates on its axis, and like the earth, revolves around the sun. The earth has four seasons, instead of two. This is because it is inclined upon its axis and receives varying amounts of the sun's light as it revolves about the sun in the solar system.

THIS OBSERVATORY, WHICH WILL HOUSE THE 200-INCH TELESCOPE, IS UNDER CONSTRUCTION ON MOUNT PALOMAR.



### 4. What well-known heavenly body turns with the earth?

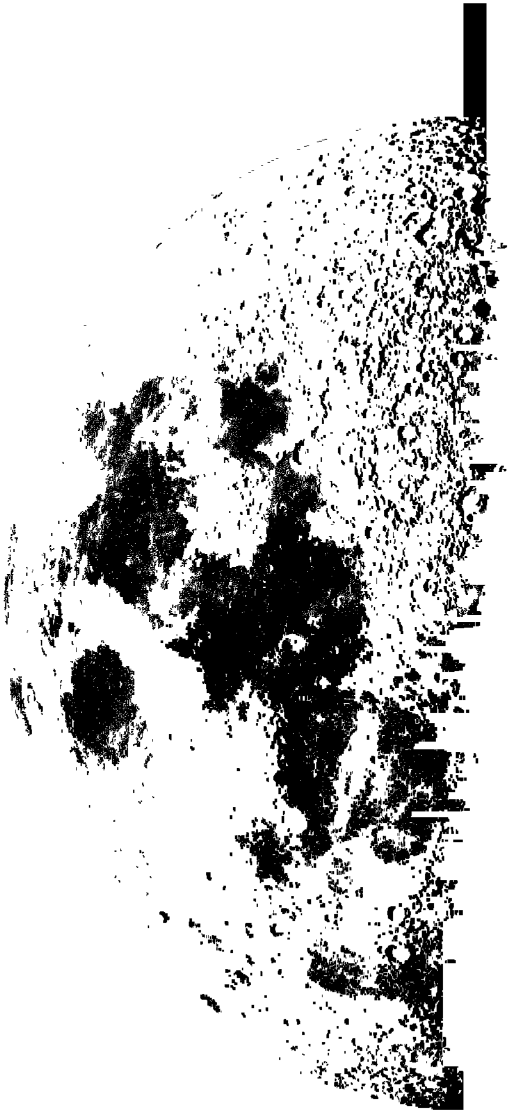
The earth, then, rotates daily upon its axis, and revolves about the sun, covering 584,000,000 miles in each complete revolution. As the earth journeys through space, it is accompanied by a companion of about one fourth the earth's diameter. This companion, the moon, is our nearest sky neighbor.

As the earth revolves once around the sun, the moon revolves nearly thirteen times around the earth. In fact, some people have proposed to make a calendar of thirteen moon months. The moon's orbit around the earth is small. The actual period of time which elapses between full moons is about twenty-nine and one-half days. The time required for the moon's revolution around the earth is probably the original basis for our division of time into months.

Some American Indians measured time by the changing moons. They called March, "The Awakening Moon"; April, "The Moon of Green Growing Things"; May, "The Planting Moon"; June, "The Wild-Rose Moon"; October, "The Leaf-Falling Moon"; and December, "The Long-Night Moon."

The moon rotates once as it revolves around the earth, and consequently the same side is always turned toward the earth. Because of this fact astronomers have been able to see only a little more than one half, or 59 per cent, of the moon's surface. Many photographs have been made of its rocky surface, in which the mountains, craters and plains show very distinctly. You can see some of these features with a good field glass, and those of you who live in cities may like to buy a glimpse through the telescope often set up on city streets on clear nights.

As the moon revolves around the earth, we do not always see all of the side that is turned toward us. As a result we



AS THE MOON REVOLVES ABOUT THE EARTH WE SEE ITS DIFFERENT PHASES. THE FIRST QUARTER OF THE MOON IS SHOWN ABOVE.

WHY CAN'T WE ALWAYS SEE THE ENTIRE SURFACE OF THE MOON? THIS PICTURE WAS TAKEN OF THE MOON IN ITS LAST QUARTER.

see the different shapes, or *phases*, of the moon. You have probably observed these occurrences numbers of times.

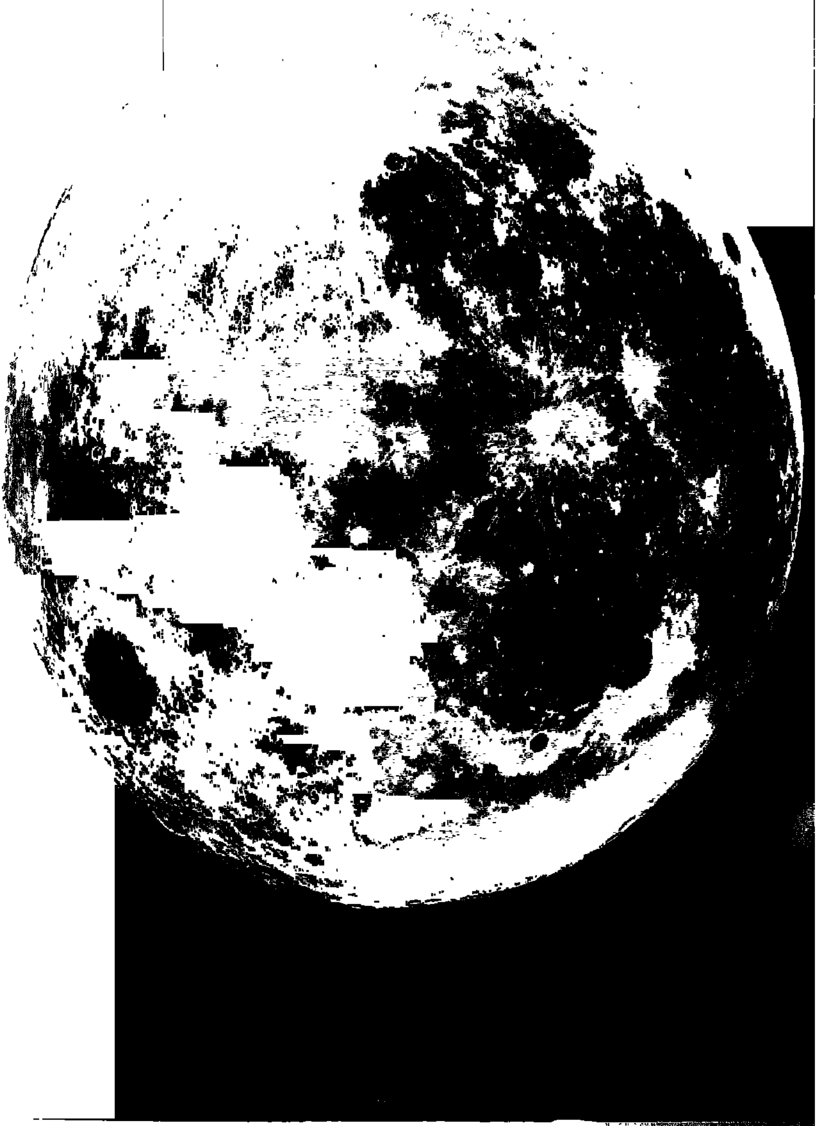
*If you have a camera, photograph the moon in its different phases and display your pictures on the class bulletin board.*

The earth's gravitational force holds the moon in its orbit, just as the sun's gravity holds the earth and the other planets in their orbits. The force of gravity is much less on the moon than it is on the earth. If there were people on the moon, they could jump six times as high as on the earth. A pole vaulter might clear six times the present world's record.

### 5. How has the moon influenced the division of the year into twelve months?

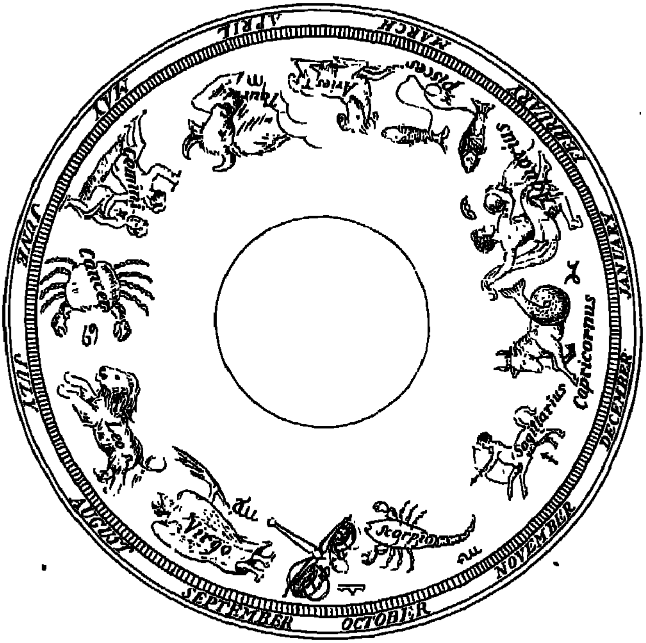
We are all familiar with the fact that the year has three hundred and sixty-five days. This means that there are three hundred sixty-five sunrises and sunsets, or three hundred and sixty-five rotations of the earth during a year. During this time we have seen the moon pass through its phases, from new moon to full moon, some twelve or thirteen times. Throughout this period of three hundred and sixty-five days, the earth has been traveling around its orbit at a speed of about 6,480 miles an hour to complete its journey around the sun. You will note that the rate of the earth's rotation and revolution are not the same.

In a year, as the earth revolves around the sun, we see different constellations at different seasons. A constellation is a group of stars which people have imagined as forming the outline of some object in the sky. Ancient people thought that twelve of these constellations were arranged around the celestial equator, which is directly above the earth's equator. These twelve constellations are called the signs of the zodiac. Zodiac comes from a Greek word meaning animals. However, only seven of the constellations of the zodiac are named after



PHOTOGRAPHS OF THE FULL MOON ENABLE SCIENTISTS TO STUDY ITS SURFACE.

animals; some are named for people. The twelve constellations which form the signs of the zodiac are: Leo, Virgo, Libra, Scorpius, Sagittarius, Capricornus, Aquarius, Pisces, Aries, Taurus, Gemini, and Cancer. Translated they are: the



AS WE TURN WITH THE EARTH WE SEE THE DIFFERENT CONSTELLATIONS WHICH FORM THE SIGNS OF THE ZODIAC.

Lion, the Virgin, the Balance, the Scorpion, the Archer, the Goat, the Water-Bearer, the Fishes, the Ram, the Bull, the Twins, and the Crab. Any of you who visit Washington will find an excellent representation of the signs of the zodiac on the floor of the Congressional Library.

There are many interesting myths concerning these constellations. According to one legend, Leo, the lion, was a beast that came from the mountains of the moon. This beast carried cattle away and killed the farmers in their fields.

The king of Nemea ordered Hercules, who was the strongest man in the world, to kill the animal and return with the skin. Years later, when the hero mounted his funeral pyre, he wrapped himself in the lion's skin. Then the lion appeared in the sky, and has continued there ever since.

Cancer is the faintest of the zodiacal constellations. The Greeks imagined that the stars formed an outline of a crab. This crab was sent by the goddess Hera to seize the heel of Hercules as he struggled with the nine-headed Hydra. Hercules crushed the crab under his heel, but even so, Hera placed the crab in the sky among the constellations.

There are stories told of each of the other signs, too long to relate here. The ancients associated definite characteristics and opportunities with the people born under the respective "signs." While we know that these beliefs are mere superstition, some people are still foolish enough to listen to astrological predictions.

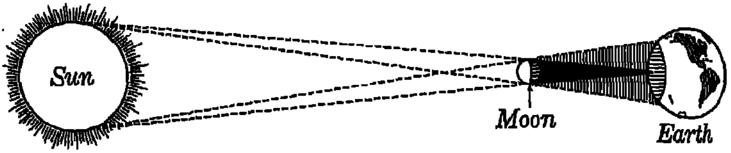
All boys and girls can learn to recognize these constellations and others too. Consult every month a star map, such as occurs in *Nature Magazine* or the *Science News Letter*, and become familiar with some of the stars that parade across the sky during the year.

*Find out when each of the constellations of the zodiac is visible, and report to the class.*

### 6. What causes a total eclipse of the sun?

As the earth revolves around the sun, carrying with it its companion, the moon, it sometimes happens that the moon passes between the sun and the earth. This shuts off the sun's light from a small part of the earth for a few minutes, causing what is known as a total eclipse of the sun. There are always two solar eclipses each year, and there may be as many as five. However, eclipses do not always occur in a locality where they can be studied. About once in every three years a total eclipse of the sun is visible from land, and even then clouds may render the spectacle invisible.

It seems strange that such a small body as the moon is able to blot out an object that has over four hundred times its diameter. We must remember that the moon is our nearest sky neighbor, and that the sun is nearly four hundred times as far away. If you will hold a saucer before your eyes, you can obscure another object as large as a barrel, a washtub, or a house. Similarly, the moon hides the sun from our view.



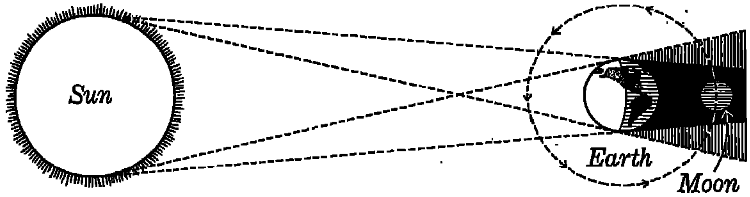
AN ECLIPSE OF THE SUN OCCURS WHEN THE MOON PASSES BETWEEN THE SUN AND THE EARTH.

Astronomers are able to know far in advance just where and when an eclipse of the sun can be observed. We shall not see another eclipse from the United States until 1963. Therefore, it will be necessary to leave the United States, if you are to view an eclipse before you are grown men and women. If your school has an instrument called a planetarium, you can understand that the moon's shadow strikes the earth at a different place at each eclipse.

When we view a solar eclipse from its beginning to its close, we observe one of the most amazing events that human beings ever experience. We see the tiny crescent of the moon coming between us and the sun. As more of the moon's surface becomes visible, we receive less light from the sun, and as a consequence a strange light, somewhat resembling twilight, covers the region from which we are viewing this eclipse of the sun. Then, after nearly an hour, the sun is entirely hidden from view. Planets and stars are visible, and the temperature falls several degrees. Birds seek their nests, thinking that night has come. After a brief period of total darkness, which can never be more than eight minutes, an edge of the sun is seen as the moon continues its revolution about the earth. More and more light is received from the sun, and in another hour the earth has resumed its usual appearance. Another total eclipse of the sun is over.

### 7. What causes a total eclipse of the moon?

We understand that eclipse means to darken. When there is an eclipse of the moon, the earth does not receive any silvery light from its smaller companion during the period of total darkness. The moon has no light of its own. Like the planets Mars, Venus, Jupiter, and Saturn, it reflects the sun's light.



AN ECLIPSE OF THE MOON OCCURS WHEN THE EARTH PASSES BETWEEN THE SUN AND THE MOON.

As the moon revolves around the earth, it may happen that the earth passes directly between the moon and the sun. The sun's light is shut off from the moon for a time, and the result is an eclipse of the moon. There may be two or three lunar eclipses in one year. An eclipse of the moon may be observed from a large part of the earth's surface. Therefore, astronomers do not find it necessary to travel great distances to observe a lunar eclipse as they often do to study a solar eclipse.

When the earth's shadow covers the moon's surface, we have positive evidence that our world is round. Why?

*Collect photographs of eclipses of the sun and the moon, and display them on the class bulletin board.* Back numbers of the *Science News Letter* will make a good source.

### 8. How is standard time determined?

When we examine a globe representing the earth, we find there are lines running through the equator from pole to pole. We shall find that there are twenty-four of these imaginary lines, called *meridians*, or lines of *longitude*.

There are 360 divisions called degrees in every circle, and the earth's circumference has been divided into twenty-four meridians with fifteen degrees between any two of the meridians. The earth rotates through a distance of 15 degrees every hour. Thus, in a twenty-four-hour day the earth has made one complete rotation on its axis.

Because the earth rotates from west to east, the sun is directly above the eastern states three hours before it is above the states on the Pacific coast. When the sun is directly overhead it is noon, regardless of where we may be.

Before watches and clocks were invented, people told the time of day or night by the sun or stars. The bright star, which we call the sun, was used during the daytime. The position of the constellations in the sky indicated the approximate time during the night. Modern people continue to use the stars as a means of regulating their watches and clocks. The time that passes between the appearance of the sun directly above a meridian on two successive days is called a *solar* day.

*Prepare a special report, illustrating it with pictures or drawings of the different devices people have used in order to tell time.*

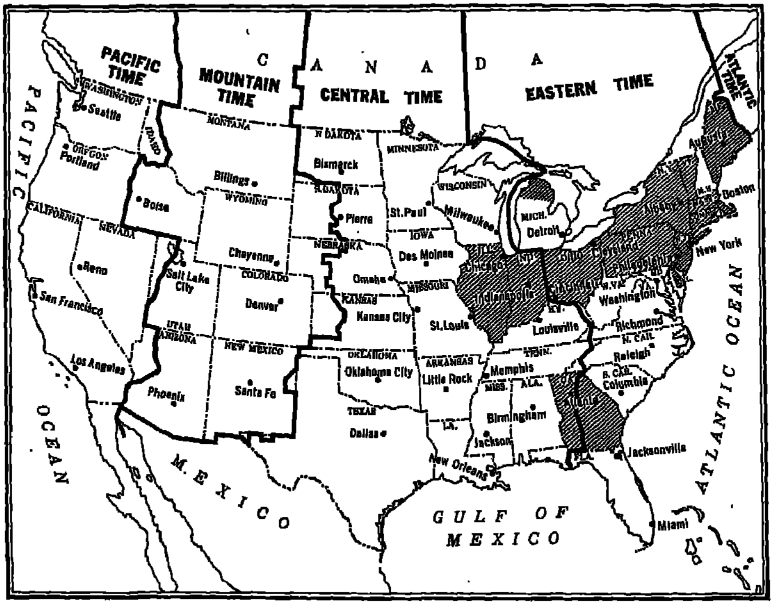
If we should attempt to regulate our clocks by sun time, we should have to set them ahead if we were to go a short distance east of our homes, and set them back if we were to travel west a short distance. This, of course, is impractical.

In order that people might have less confusion about the time, an international conference was held in Washington, D. C. in 1884. At that time it was decided that all of the civilized nations would adopt standard time. Standard time, for the world, is counted from Greenwich, England, through which the prime meridian (the meridian marked 0 on maps) passes.

Every town and city within the United States is in one of the four time zones as you can see from the map on page 212. Boys and girls who live in the eastern time zone have been in school three hours when those who live on the Pacific coast report for school at half past eight in the morning. When school people who live near Omaha and Chicago are excused at three o'clock in the afternoon, the boys and girls near Seattle and Portland, Oregon, are beginning their afternoon classes. You can easily understand that New York City and San Francisco do not have the same time, if you will listen to the announcements of radio programs that originate in these cities.

*Daylight-saving time* was widely introduced into the United States during the World War. At the present time daylight-saving time is used in only a few of the most thickly populated states. However, one fourth of our population appreciates an added hour of daylight during the summer evenings. When people in some of the eastern localities go to bed on the last Saturday night in April, they turn their clocks and watches ahead one hour. When the last Saturday night in September arrives, the clocks and watches are set back one hour. Then, for eight months these people, like the other three fourths of the people in the United States, use standard time. When people live in large cities and must spend considerable time in reaching their homes after working hours, daylight-saving time, or summer time as it is sometimes called, allows more outdoor recreation in the evenings.

When people travel westward from San Francisco, or Seattle to China, Japan, and other places in the Orient, they pass an imaginary line near the middle of the Pacific Ocean, called the *International Date Line.* Find this line, which is drawn near the 180th meridian, on a globe of the earth. This line was chosen by international agreement because it does not touch land on either side. When ships are sailing toward the Orient, a day is added when this line in mid-Pacific is reached. If traveling toward the United States, a day is lost or dropped out entirely.



AS WE TRAVEL EAST AND WEST ACROSS THE UNITED STATES WE CHANGE OUR WATCHES SEVERAL TIMES. ON THE MAP ABOVE THE SHADED AREAS IN THE EAST HAVE SUMMER DAYLIGHT SAVING TIME IN MOST OF THE CITIES AND TOWNS.

When the New Year comes to Greenwich, England, the clocks in the different parts of the United States and our territorial possessions are widely different. In New York City, Boston, and Philadelphia the time would be seven p.m., December 31. What time would it be in Chicago? In Denver? In San Francisco? Out in the Hawaiian Islands, the time would be one-thirty on the afternoon of December 31. In Alaska, artificial light might be necessary to learn the time, which would be two o'clock on the afternoon of December 31. And out on the tiny Island of Guam, the time would be nearly ten o'clock on the morning of New Year's day.

*Listen to a radio receiver on the hour or half hour to catch the announcements of programs. Try to get programs scattered across the country. What time is it at home? What time is it in New York, Cincinnati, Chicago, Cleveland, Atlanta, San Francisco, and Portland, Oregon?*

### 9. How can we locate places on the earth's surface?

*Meridians,* or lines of longitude, have been described as imaginary lines which run around the earth from pole to pole. If we examine maps or a globe of the earth, we shall find other lines which run around the earth parallel to the equator. These imaginary lines are called *parallels of latitude.*

The equator is the zero parallel, which divides the earth into the northern and southern hemispheres. The distances north and south of the equator are divided into 90 divisions called degrees. Through these divisions imaginary lines, called parallels, extend around the earth. See map on page 39. You will notice that parallels are actually drawn only every 10°. Latitude helps to determine the climate of a region. The farther we go from the equator, the colder we expect the climate to be.

Every spot on the earth's surface has a meridian as well as a parallel running through it. Meridians and parallels are divided into degrees, minutes, seconds, and fractions of seconds. Any point on the earth's surface can be indicated with exactness by means of the imaginary lines of latitude and longitude.

The Greenwich, or zero meridian, and the equator are the points from which the location of any place on the earth is measured. Every place is so many degrees, minutes, and seconds of latitude north or south of the equator.

### THINGS TO DO

1. Look up the myths connected with some of the constellations that belong in the zodiac and report to the class.
2. Find out how many round trips between San Francisco and New York City would have to be made to equal the distance that the earth covers each year as it journeys around the sun.
3. Collect news items which show variations in time throughout the world, and arrange them on the class bulletin board.
4. Get a copy of the latest edition of the *World Almanac* from the school library. Find the section on standard time. On the blackboard make a table to show the time in principal cities of the world when it is noon in New York City.
5. The planting directions on most packages of garden seeds are given for the latitude of Philadelphia. From a map or globe find the nearest parallel of latitude to Philadelphia. How far north or south of this line is your home? How much allowance should be made in season due to the distance north or south of Philadelphia?
6. Can you construct a moving model of the earth to show its inclination on its axis? Set your model so that a beam

of light falls on the earth from one side. Let the light beam represent the sun. Can you show the effect of the inclination of the earth with your apparatus?

7. Make a record of the time that you can first see the moon on each of three successive nights. What is the difference in time?
8. What is the location of your city or town in terms of latitude and longitude?
9. What cities in South America are approximately as far south as St. Louis is north?

### SOME THINGS TO REMEMBER

1. The rotation of the earth causes day and night.
2. Days and nights are of unequal length because the earth is inclined on its axis at an angle of 23½ degrees.
3. The planets are held in their orbits by the gravitational pull of the sun and centrifugal forces.
4. Sir Isaac Newton discovered the laws of gravitation.
5. We measure the earth's gravity for objects on its surface in pounds or in grams.
6. Tides are caused mainly by the moon's gravitational attraction.
7. The four seasons are caused by the earth's revolution around the sun and by the inclination of the earth's axis.
8. The word equinox means equal days and nights.
9. The word solstice means the standing still of the sun.
10. We see the different phases of the moon as it revolves around the earth.
11. A total eclipse of the sun occurs when the moon passes between the earth and the sun.
12. A total eclipse of the moon occurs when the earth passes between the moon and the sun.
13. The earth's rotation is used in determining standard time.
14. The earth is divided into twenty-four time-zones by the meridians or lines of longitude.

15. There are four different time-zones in the United States.
16. The parallels of latitude run north and south parallel to the equator.
17. Any point on the earth's surface can be indicated exactly by means of the imaginary lines of longitude and latitude.

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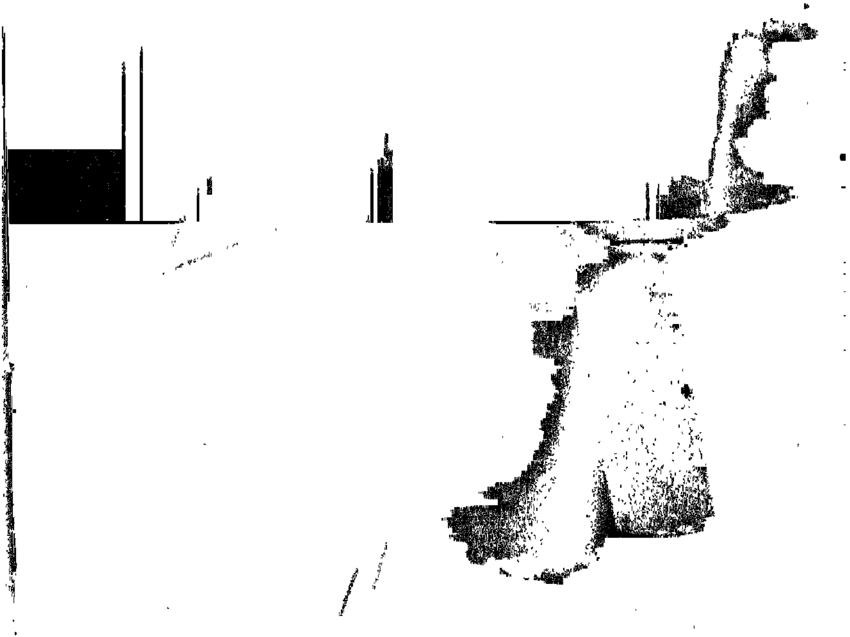


# UNIT SEVEN

## UNIT SEVEN

# What Are Things Made Of?

### WHAT THIS UNIT IS ABOUT

Have you ever looked at what appeared to be a simple substance under a microscope or a hand lens? Were you amazed to find that what seemed to be one solid substance turned out to be made of a great many smaller pieces? Even if you look at the back of your own hand under a large hand lens it seems to be made up of a great many small pieces. Are the smaller particles of which many substances seem to be made the building blocks of nature, or are there still smaller pieces? Are the true building blocks of which all substances are made even smaller than things which you see under a microscope?

Have you heard such terms as chemical elements and chemical compounds used? What do these words mean? Many new kinds of substances are being put together by scientists known as chemists. What does a chemist do? With what kinds of knowledge does the subject of chemistry deal? Of what use is chemistry to those of us who do not intend to become chemists? Do we have any chemical substances about our own homes? Is it possible that we are concerned with any chemical changes in our ordinary living?

What becomes of the food that you eat? How is it possible that milk, bread, and apples can become a part of a boy or girl? If a stick of wood is burned in a fireplace, does part of the wood just disappear with the smoke that goes up the chimney, leaving only the ashes on the hearth? What becomes of the smoke?

If you pour a tablespoonful of table salt into a large tumbler of water and stir it, the salt seems to disappear. If you hold the glass to the light you cannot see the salt. If you taste the water, its taste has changed. What has happened? Can you recover the salt?

Suppose you should put half a teaspoonful of baking soda in a glass dish, adding a weak acid—lemon juice or vinegar will do—to the soda, a very little bit at a time. What happens? What becomes of the soda? Can you get all of the soda back? What becomes of the acid?

Can you make any application of what you have found out about baking soda? What makes the bubbles? What does baking soda do in some kinds of breads and cakes?

In this unit we shall try to help you to get some answers to problems like these. We shall try to find out something about how the substances of nature are put together. You will find a list of the problems with which this unit deals on the following page. Do you have others of your own like these that you would like to have answered?

# What Are Things Made Of

## UNIT PROBLEMS

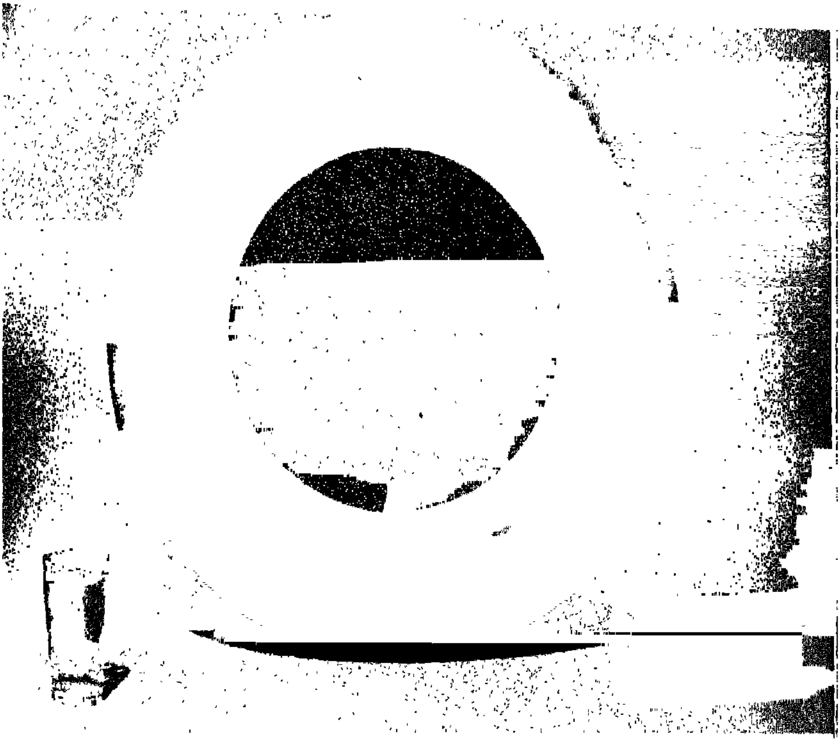
1. What are solids, liquids, and gases?
2. What are chemical elements?
3. What is the difference between a mixture and a compound?
4. What happens when a fuel burns?
5. What elements are found in some common chemical compounds?
6. How do we "burn" foods in our bodies?
7. Why do we need water?
8. Of what are we made?

### 1. What are solids, liquids, and gases?

If we ask how the things of our world are put together, we find that different things have different appearances.

A piece of stone is heavy; it is solid; it seems to be all in one piece; you cannot see through it. If you let the stone fall, it drops in one piece. If you take it into your hands, it does not bend.

On the other hand, a quantity of water has qualities that are different from those of the stone. The water has weight, but you can thrust your hand right through it. It runs together again when you take your hand away. You can see through the water to the bottom of the vessel that contains it. You must keep the water in a container, or it spreads out or runs



THE THREE FORMS OF SUBSTANCES ARE SOLIDS, LIQUIDS, AND GASES. EXAMPLES OF THESE ARE A BRICK, WATER, AND THE AIR IN AN AUTOMOBILE TIRE.

away. If you turn the water out of its container, instead of falling in one piece, it runs or pours from the vessel.

*In the science storeroom at school find a bottle of ammonia water. You may find a solution labeled* ammonium hydroxide. *Take out the stopper. Bring your nose cautiously over the bottle. Do not get too close to the mouth of the bottle. Note the strong, sharp odor and the stinging sensation in your nose and eyes.* Something is escaping from the bottle. It does not pour, because the liquid is still in the bottle. It does not fall on the floor like a stone. You cannot grasp it and you cannot see it, and yet there must be something present that causes the sharp odor and the stinging sensation.

Objects like the stone we call solids. Materials which behave in many ways like water are called liquids. Substances such as the fumes from the ammonia bottle are gases. Sometimes we speak of the forms of the substances that we see all around us as *the three states of matter*. Very simply, this means that all the materials of our world are either solids, liquids, or gases.

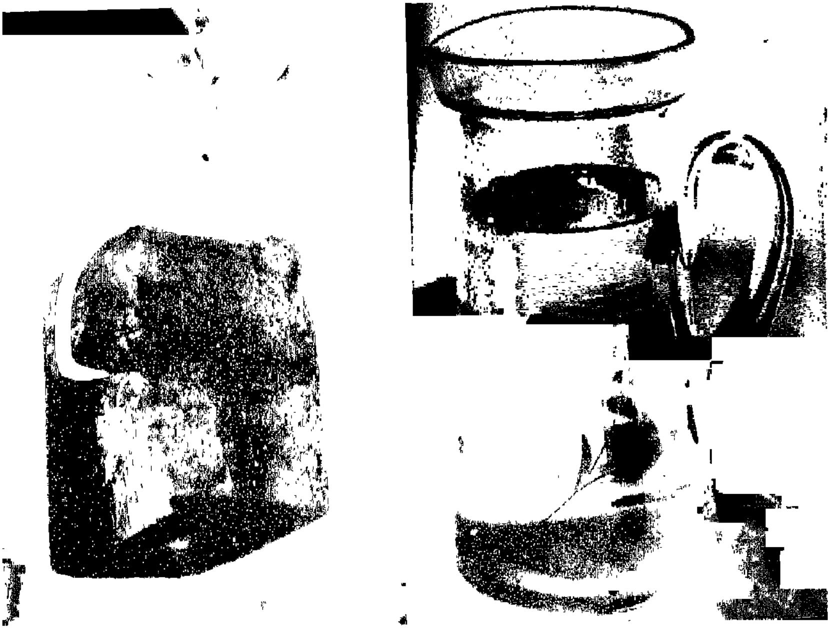
Familiar solids are wood, iron utensils, paper, copper, cotton, bread, a lump of sugar, a book, a pencil, a piece of coal, and a candle.

Liquids are water, vinegar, syrup, gasoline, kerosene, lemon juice, cider, mercury, and alcohol. You can think of others.

Some gases are air, oxygen, carbon dioxide, hydrogen, illuminating gas, natural gas, the gas from gasoline, ammonia, and others.

Many substances exist in more than one of the states of

SOME SUBSTANCES CAN EXIST IN ALL THREE STATES OF MATTER.



ICE WATER

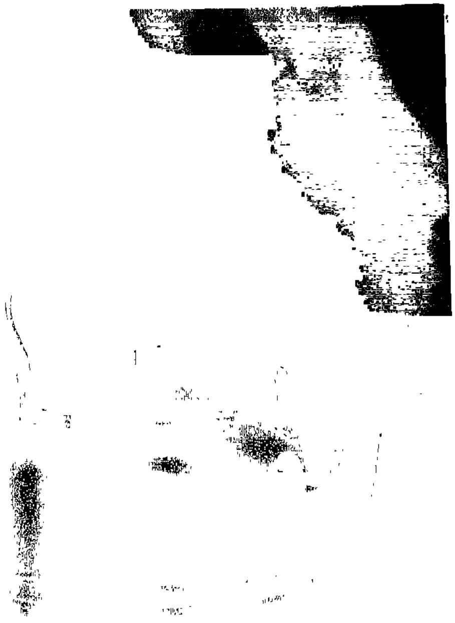
matter. To say this in another way, a substance can often be changed from one of these states into another. A familiar illustration is that of water. Ordinarily we think of water as a liquid. On the other hand, if it becomes as cold as 32° F. or lower, water turns into ice, a solid. If we heat water until it boils, 212° F., the water turns into water vapor, a gas.

Is the inner composition of water changed when it changes from a liquid to a solid? Explain.

There are many other examples of changes of state that you know. When you buy gasoline for the automobile, you buy it as a liquid at so much per gallon. The fuel that burns in the automobile motor to pull the automobile is a gas, however. The liquid gasoline turns quite easily into a gas. Warming the gasoline makes the change take place more readily. Keeping the gasoline cold slows up the change. You know, of course, that an automobile is harder to start in winter weather than it is in summer. The difficulty is that the cold liquid gasoline does not turn into gas so readily as it does in summer.

Probably you think of sugar as a solid. If you put the sugar into a pan and heat it, it turns into a syrup which is a liquid. A candle is a solid. When you burn the candle some of the wax melts into a liquid and runs down the candle. As it cools, it becomes solid again.

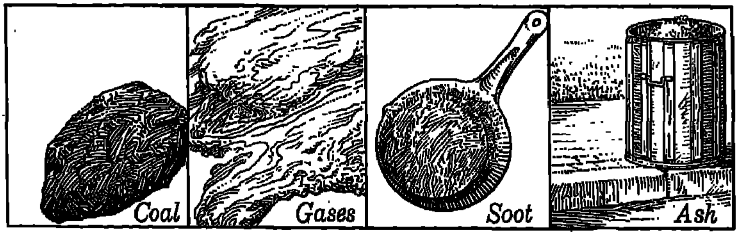
STEAM OR WATER VAPOR



You will have noticed by this time that changes in the state of a substance happen when there are changes in temperature or changes in pressure. Iron can be melted into a liquid if the temperature is high enough. Mercury can be frozen into a solid if the temperature is made low enough. Water freezes if the temperature is made low enough and changes to water vapor when the temperature is raised sufficiently high.

Often it is necessary to increase or lower the pressure as well as change the temperature to make a change in the state of a substance. Air can be turned from a gas into a liquid at high pressures and very low temperatures. Gases in mechanical refrigerators are cooled and compressed to change them into liquids. The purpose of the pump, or compressor, in the refrigerator unit is to increase the pressure to turn the gas into a liquid. The pump serves also to lower the pressure on one side of the system. As the liquid escapes into the part of the system having a low pressure, it suddenly expands into a gas again. It is this change which produces the cooling inside the refrigerator.

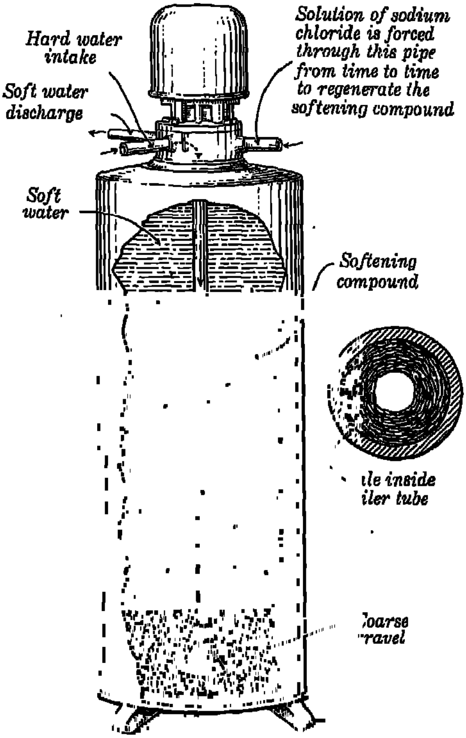
We depend upon changes of this kind for all of our rainfall. Water exposed to the air slowly changes to water vapor. This process takes place more rapidly when it is warm. Water exposed to the sun evaporates, or changes to water vapor, very quickly. This water vapor mixes with the air and drifts



WHAT IS IN A LUMP OF COAL?

away with currents of air. If the air is chilled, the water vapor condenses or turns back into water. The water is in the form of very tiny drops. These run together into familiar raindrops as the air currents are thrown together in the cooling process.

A few substances pass directly from a solid state into gases without becoming liquids. This is sometimes true of ice. In cold weather a piece of ice gradually decreases in size as the ice turns directly into water vapor without melting. The water vapor disappears into the air. After awhile the piece of ice disappears without melting. Iodine can be changed directly from a solid into a gas without its becoming a liquid. *You might try gently warming a few bits of solid iodine. Do not breathe the gas. What we commonly know as liquid iodine, tincture of iodine, is a solution of solid iodine in alcohol.*


Hard water intake
Soft water discharge
Soft water
Solution of sodium chloride is forced through this pipe from time to time to regenerate the softening compound
Softening compound
le inside
iler tube
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HARD WATER CONTAINS VARIOUS MINERALS.

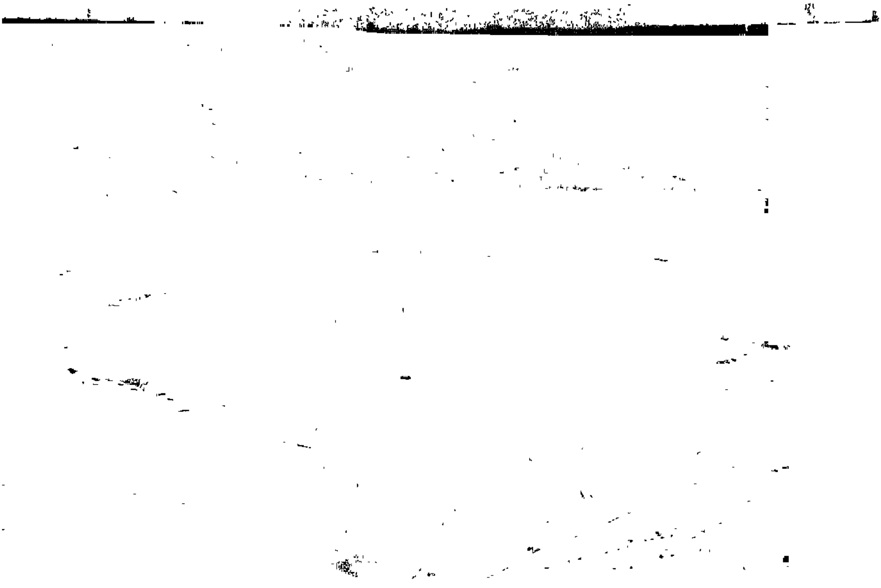
## 2. What are chemical elements?

*If you will examine carefully a good-sized piece of coal, you may be able to see several kinds of substances in it. It* *may be necessary to break the piece open with a hammer. You will see some material that is coal and probably some pieces that are rock. You may find some slate. If you burn a small amount of coal, the coal seems to disappear. Smoke and gases are soon lost in the air. Any vessel that is held in the smoke, especially from soft coal, is blackened with soot that somehow comes out of the coal. After the coal is burned, you will find some materials left that we call ash or cinder. If there was rock or slate in the piece, these will be left in the ash.*

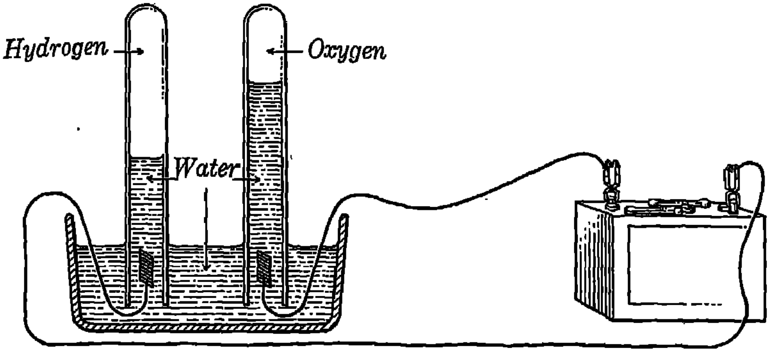
Is it not apparent that what seems to be one solid piece of material at first is truly a mixture of several substances?

This is also true of many other things that we find all about us, not only for solids, but also for liquids and gases. Ordinary water as we find it in nature is a mixture. Hard water contains various minerals. This you can see by boiling off the water and examining the scale left in the vessel. Creek water is a mixture of water, clay, sand, and other substances. The soil is also a mixture of many things.

THE IRON MINE AT HIBBING, MINNESOTA, IS THE GREATEST IN THE WORLD.



Very often we have problems that are concerned with separating substances from mixtures. The softening of hard water is a matter of separating from the water the minerals which cause the hardness. In any city-water-supply system, a part of the problem of conditioning the water for human use is the separation of mud and other substances from the water. Nearly all of the metals which we use in our tools and machines are found mixed with other substances in the rock of the earth. In order to recover the metal, it is first necessary to separate the ore containing the metal from the rock mixture in which it is found. (See also page 239.)



WATER CAN BE SEPARATED INTO THE TWO GASES OXYGEN AND HYDROGEN.

Our question about the nature of substances goes farther, however. Can we break into simpler substances those things that appear to be just one substance? For example, what is in pure water? It is possible to separate water into its parts. This can be done by passing an electric current through water. When this is done the water is broken down into two gases, hydrogen and oxygen. The process is called electrolysis. The apparatus used is shown in the diagram.

It is probable that your science teacher will demonstrate this process for you.

These two gases are combined always in the same definite proportion to form water. We might say that water always has exactly the same recipe, and so is made up of the same two gases in exactly the same proportions. For water, the proportions are two volumes of hydrogen to one volume of oxygen. You should be able to see the proportions in the demonstration which the teacher will carry out in the classroom.

It is also possible to put hydrogen and oxygen together to form water. There are several ways to do this. Very often when hydrogen and oxygen are mixed, violent explosions take place. Since over 20 per cent of the air is oxygen, and since hydrogen burns very readily, mixtures of hydrogen and air are often very explosive. This is the reason that hydrogen is not a good gas for filling dirigibles. In these explosions water is formed by the uniting of the hydrogen and oxygen. We could form water, then, by burning hydrogen in air, or in oxygen. This might be a dangerous experiment. *A simple way to get water from hydrogen and oxygen is to burn an ordinary wax candle. The candle wax is chiefly a compound of hydrogen and carbon. If the candle is burned, the hydrogen unites with the oxygen from the air to form water. If you will cool a glass beaker and hold it upside down over a candle flame, you may be able to collect drops of water from the burning candle.*

You may now properly ask if it is possible to break down such substances as hydrogen and oxygen into other simpler substances. The answer is no. Such things can be separated into smaller particles, but these still have the properties of the substances of which they are parts. We call these elementary substances which make up all the various things in our world *chemical elements,* or often just *elements.* There are now 92 of these elements known, although later findings may add to this number. All of the substances that we know on the earth are elements or made up of combinations of two or more of these elements, either in compounds or in mixtures.

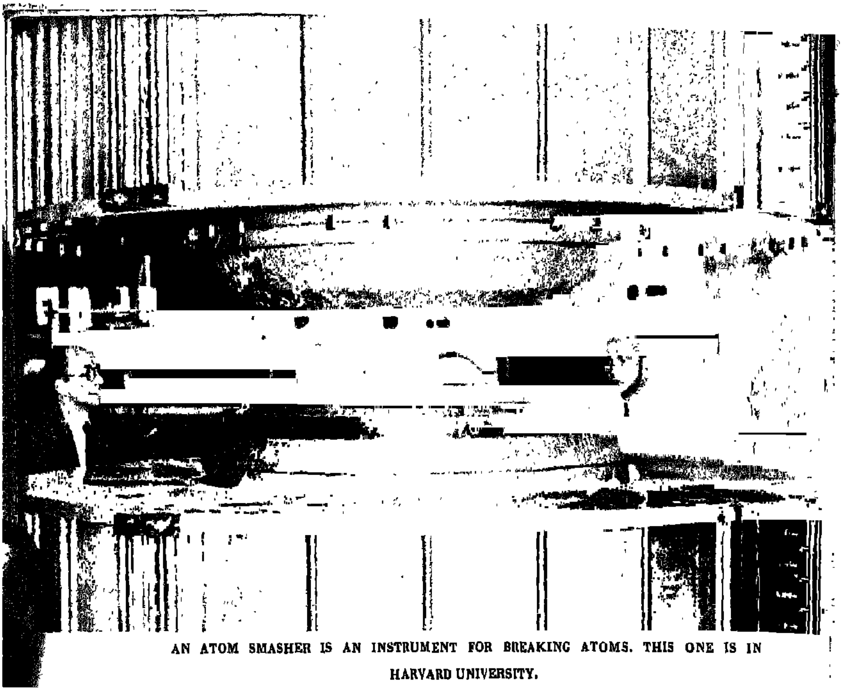
Familiar substances that are elements in their pure states are such things as oxygen, hydrogen, neon, iron, copper, silver, aluminum, mercury, iodine, sulphur, and nitrogen.

The commonest elements in the crust of the earth are oxygen, silicon, aluminum, iron, calcium, sodium, potassium, and magnesium. These eight elements make up more than 98% of the earth's crust. Oxygen accounts for 46.71%, and silicon for 27.69%. You can see some comparisons by knowing that carbon makes up only .094% of the crust, and such elements as copper and lead, .01% and .002%.

Many elements exist in large enough amounts that they can be observed or handled. They can be recognized by some properties which we can experience with our senses, such as seeing, feeling, tasting, smelling, or weight estimating. Such elements are the common metals, iron, copper, lead, zinc, and mercury. Calcium, carbon, and sulphur also can be distinguished by such properties. Other elements are more difficult to observe. For example, oxygen is colorless, odorless, and tasteless. Although we can bottle it in some container, we cannot see it as we can see such a solid as iron. We know oxygen chiefly by its behavior, especially its behavior with other substances. This same thing is true of most other elements that are gases at ordinary pressures and temperatures.

*Make a collection of substances that are chemical elements in a pure state. Label these with common names and set up an exhibit of them for other people in the school.*

Some elements exist in very small quantities in any one place. Often these can be separated from other elements only with the greatest difficulty. It has been solely by the most painstaking efforts by men of science that they have become



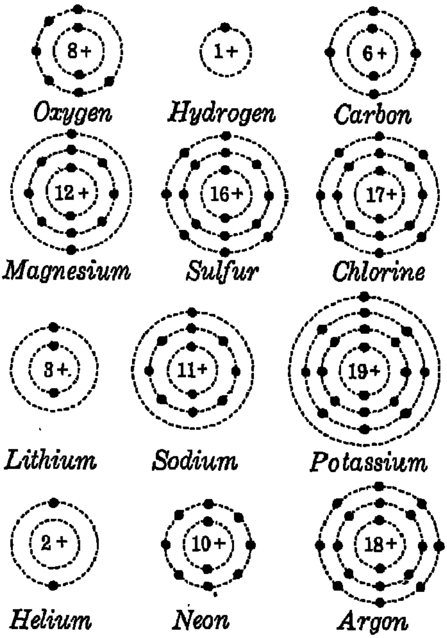
AN ATOM SMASHER IS AN INSTRUMENT FOR BREAKING ATOMS. THIS ONE IS IN HARVARD UNIVERSITY.

known at all. Often we know such elements almost entirely by their behavior in relation to other substances. The continued struggle of men and women to learn more about how our world is put together accounts for the fact that we know that some of the 92 elements exist at all. The fascinating story of the work of Mme. Marie Curie in the discovery of radium is a good illustration of such investigation.

This effort to find out about the "stuff" of our world has led scientists to try to find out how the elements themselves are put together. They now believe that elements consist of very small particles which they call *atoms*. Unlike a mass of an element like iron, which we can see and feel, we know atoms only by their apparent behavior in the substance in which they are found. Atoms are very much smaller than any bacteria that we know. They cannot be seen with the most powerful microscope.

The search has gone even further. You may read in your morning newspaper, or in this week's issue of your favorite science magazine, that some famous scientist, or some great laboratory, is building an atom smasher. Pictures of these show enormous machines using large charges of electricity. See the picture on page 230. Such machines are to be used to break up further these very minute particles of atoms that no one has ever seen.

We now believe that atoms of elements are made of very small particles or charges of electricity. Some of these charges are positive and some are negative. The positive ones are *protons*, and the negative ones *electrons*. Protons and electrons are arranged in definite patterns to form the atoms of the different elements. There is also a fixed number of protons and electrons in each of the atoms of each element. The number and the pattern of these particles determine the kind of element which the atoms form, and the properties or characteristics which the element will have.



DIFFERENT ELEMENTS HAVE DIFFERENT NUMBER PATTERNS OF PROTONS AND ELECTRONS.

We believe in these bundles of energy as parts of atoms, because substances behave as if they were constructed in this way. If we cannot see atoms, we certainly cannot see protons and electrons. We have some evidence of the existence of such things, because in their movements these bundles of energy, or electricity, leave streaks on a photographic plate. We can take pictures of their movements even though we cannot see the particles. Such an element as uranium breaks down into other substances by losing charges of energy that make up its atoms. As these move out into space their paths can be photographed.

### 3. What is the difference between a mixture and a compound?

As you have seen, it is hard to separate some elements from the substances of which they are a part. Most things as we find them in nature, or manufacture them in industry, are compounds of elements, or mixtures. The air is a mixture of gases. Pure water is a chemical compound of the elements hydrogen and oxygen. Creek water is a mixture of the compound water, with mud, sand, and other substances.

*Get a sample of creek water. How can you separate the materials mixed in this sample? Try out your proposed scheme. How can you be sure this water is safe to drink? Outline a process for treating such water for drinking purposes.*

PHOTOGRAPHS CAN BE TAKEN OF ELECTRON PATHS.

A compound is a combination of two or more chemical elements into a substance that has definite properties of its own, that are different from the properties of the elements that make up the compound. For example, as we have seen the gases oxygen and hydrogen unite to form water. Both oxygen and hydrogen are gases. Hydrogen is lighter than air. Hydrogen will burn in oxygen. These are properties of the elements oxygen and hydrogen. Water has properties that are different from those of either of the gases forming it. Water is transparent, but it can be seen. At ordinary temperatures and pressures it is a liquid, and not a gas. Water does not burn. Water is much heavier than air. Perhaps you can think of other properties of water. *Name as many properties of water as you can.*

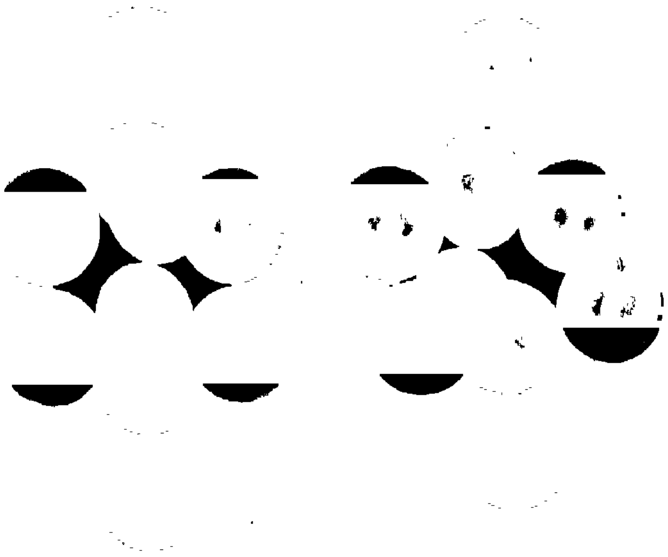
The same elements always can unite to form the same compounds and in the same relative amounts or proportions. We can say this in another way, by saying that each compound has a definite pattern or recipe and always has in it the same elements in the same proportions. If the proportions of the elements making a compound are changed, some other compound is usually formed. For example, the elements carbon, hydrogen, and oxygen unite to form starch. Another proportion of these same elements makes alcohol. For these two compounds the elements are the same, but the amounts of the elements differ in the two.

A mixture is different from a compound in that the substances in a mixture do not unite to form new substances, but still have their original properties. It is often possible to separate elements from mixtures by simple processes. Air is a mixture of gases. Oxygen mixed in air still has all of the properties of pure oxygen.

Mixtures are often made up of compounds, or of some elements and compounds. Air contains the elements oxygen, nitrogen, helium, and neon, with some rarer ones. It also contains small amounts of the compounds carbon dioxide, water, and often other gases that are compounds, such as the furnace gases escaping from chimneys.

The amounts of materials in a mixture change at different times. As we have seen, the amount of water vapor in the air mixture changes from day to day and from hour to hour. Pure water is always a compound of the two elements oxygen and hydrogen in the proportions of two parts of hydrogen by volume to one part of oxygen. Rain water, which is a mixture, contains water with some dissolved gases, perhaps some mud, often some germs, and other substances. The proportions of these impurities change with the samples of water taken at different times and at different places.

If we try to break up compounds into simpler parts, they can be separated into elements. The smallest part of a com-



A MODEL SHOWS THE ARRANGEMENT OF MOLECULES IN LIQUID WATER.

pound that can exist as a compound and have all of the properties of a particular compound, we call a *molecule.* We also think of molecules of elements. The molecules of any element contain atoms that are all alike. The molecules of a compound contain two or more kinds of atoms. If the atoms within the molecules of a substance are all alike, the substance must be an element. If the molecules contain more than one kind of atom, then the substance in question must be a compound.

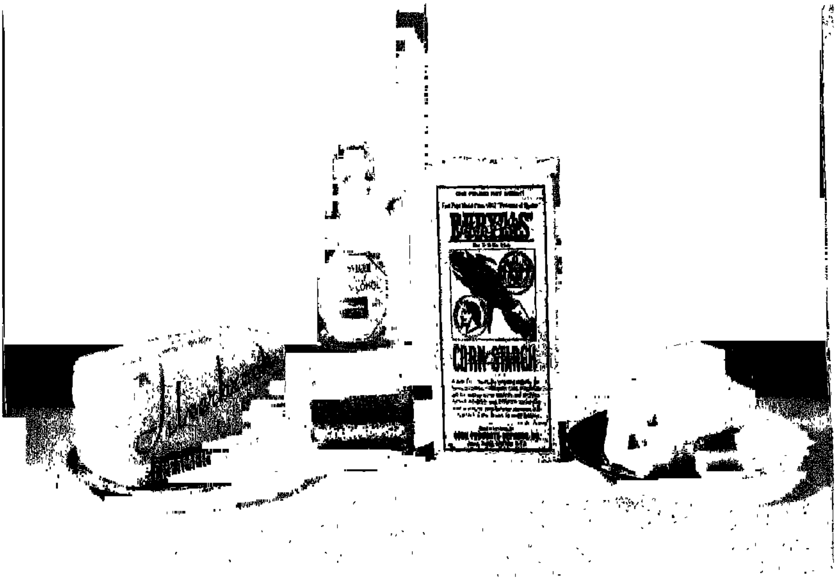
### 4. What happens when a fuel burns?

Our common fuels are mixtures or compounds. Coal is a mixture. The compounds that burn are chiefly compounds of carbon and hydrogen. Gases manufactured from coal to be burned as fuel are also mostly compounds of these two elements. Natural gas and fuel oil are mixtures of compounds formed from these same two elements in differing proportions.

Burning is really a chemical change in which the elements of the compounds in the fuel combine with oxygen to form other compounds. In most burning, the oxygen comes from the air. In this change much heat is produced. Often when the fuel is confined the sudden expansion of heated gases makes explosions that are very forceful. Such explosions can be most destructive. If we are able to control the explosions we can develop heat engines, such as the gasoline motor, to do useful work.

In these common fuels the carbon from the fuel compounds unites with oxygen from the air. One of the commonest products is the gas carbon dioxide. Other gases are sometimes formed. One of these is carbon monoxide. This is a deadly poison and is the cause of many cases of illness and death when automobiles are operated or motors left running in closed garages.

The hydrogen from these fuel compounds unites with



THESE COMPOUNDS CONTAIN THE SAME CHEMICAL ELEMENTS, CARBON, OXYGEN, HYDROGEN, BUT IN DIFFERENT PROPORTIONS.

oxygen from the air to form water. If the fuel which is being used is not completely burned, then other gases are formed.

Soot is chiefly carbon and it is left when some of the carbon from coal, wood, oil, or gas does not combine with oxygen from the air. Ashes left from coal and wood are due to the presence of mineral substances in the fuels which do not combine with oxygen in burning. Can you explain why soot is sometimes left in burning gas, oil, or gasoline? Why do these fuels leave no ashes?

*Place some wood chips in the bottom of a hard-glass test tube. Fit a small bore glass tube into a one-hole rubber stopper. Fit the stopper into the test tube. Heat the wood chips in the flame of a Bunsen burner. Will the gas that is given off burn? Caution! Allow the gas to escape from the tube long enough to remove the air before trying to light it. This will prevent an explosion. What is left of the wood in the test tube? Will this substance burn? Explain as well as* *you can what becomes of the wood and what has taken place in the process of the heating. Try this experiment with coal chips.*

### 5. What elements are found in some common chemical compounds?

It is possible to burn such elements as carbon or hydrogen. As we have seen, most fuels are compounds of these two elements. Wood is chiefly a chemical compound called cellulose containing the elements carbon, hydrogen, and oxygen. The woody fibers of all plants are cellulose.

Starch is another of these plant compounds with the same elements in different proportions. Sugar is also a compound of these three elements. There are many different kinds of sugars, but when we speak of sugar we usually mean cane or beet sugar. Cane and beet sugar have the same chemical composition, and are, therefore, the same kind of sugar. There are, however, many kinds of sugar having different compositions; that is, having carbon, hydrogen and oxygen in different proportions. For instance, grape sugar has a different combination of these three elements from cane or beet sugar.

The foodstuffs composed of hydrogen, oxygen, and carbon we sometimes call the carbohydrates. In these compounds the hydrogen and oxygen occur in the same proportions that they do in water. The carbohydrates include all of the starchy and sugary foodstuffs, the cellulose of wood, and cotton fiber. They are manufactured in nature in the green parts of plants. The raw materials come from carbon dioxide taken from the air through the leaves of the plants and from water which comes up through the roots of plants.

Alcohols are made from starch, sugar, cellulose, or wood. The compounds contain the same elements as the carbohydrates, but in different proportions.

Fats and plant and animal oils have the same chemical elements as the carbohydrates, but in much more complicated formulas. There are many different kinds of fats and oils just as there are many kinds of sugars. Common examples of oils are olive oil and cottonseed oil.

Food substances that are very complicated compounds of nitrogen, with hydrogen, oxygen, carbon, and sulphur, are called proteins. They are especially rich in nitrogen. Proteins exist in lean meats, in many vegetables and grains and in white of eggs. These furnish the growth materials for the cells of our bodies.

The common metals, such as iron, aluminum, copper, lead, zinc, gold, and silver, are chemical elements. They form many compounds. All of these combine, usually rather slowly, with oxygen. Iron rust is a compound of iron and oxygen. Rusting of iron in moist air is considered as a slow burning.

COAL AND BREAD ARE TWO FUELS THAT COMBINE WITH OXYGEN TO PRODUCE HEAT TO KEEP US WARM. CAN YOU TELL WHAT TAKES PLACE IN EACH CASE?

Most of the metals are not found as pure elements free in nature. Chemical compounds of them are found. These minerals are often compounds of the metal with substances such as oxygen or sulphur. The mineral compounds are mixed with other substances in the rock. To get a metal it is necessary to get the mineral out of the rock mixture, and then treat it so that the metal is separated from its compound. This treatment is often a process in which the unwanted element of the compound joins with some other elements in a mixture to form new compounds, leaving the wanted metal free. (See also page 227.) This latter process usually requires heating the metal or the compound containing the metal and any other added substances.

*Arrange an exhibit of some common chemical compounds. On the label for each place the common name of the compound and a list of the elements of which it consists. Can you find the chemical formulas for these compounds in chemistry textbooks? Your label should look something like this:*

SUGAR
Composed of hydrogen, oxygen and carbon
$C_{12}H_{22}O_{11}$

### 6. How do we "burn" foods in our bodies?

The heat which keeps our bodies warm, and the energy we need to move about and work, come from the chemical combination of oxygen with the foods which we eat. This process is sometimes called oxidation. Ordinary burning of fuels is also oxidation. So is the rusting of iron. Since the chemical process is the same as that in burning, we often speak of burning fuel-foods in our bodies.

The fuel-foods which furnish the energy and heat for our bodies are the carbohydrates and the fats. You will remember that these contain the elements carbon, hydrogen, and oxygen. You will also remember that two of these are the elements which occur in all of our fuels. Two of the compounds formed in this burning of energy-fuels are carbon dioxide and water. These are given off from the lungs in breathing.

You are familiar with the process of seeing your own breath in cold weather. This happens when it is cold enough to condense the water vapor in the breath to small droplets of water that become visible in the air. You can get something of the effect by breathing on a cold windowpane or mirror. The glass becomes fogged with drops of moisture as these condense on the cold surface.

A test for the presence of carbon dioxide is that it forms small white particles, a *precipitate,* in limewater. You can make limewater by dissolving slaked lime in water. *Put some slaked lime in a glass of water and stir thoroughly. Let this stand for ten or fifteen minutes. Be sure that the water at the top is clear. Carefully pour off the clear water. This is the limewater. Now bubble your breath through a glass tube into the limewater. Do you get a white precipitate? If you do get a white precipitate, it shows that there is carbon dioxide in your breath.*

The food eaten comes in through the mouth and passes on down through the digestive tract. It is chewed and mixed with digestive juices in the mouth. As it passes on through the parts of the digestive tube, it is further mixed with other substances which break part of it down into materials that are dissolved in the water taken into the body. These dissolved substances pass through the walls of the small intestine into the blood stream. The blood carries the dissolved food

A FIELD OF THIS KIND IS A MARVELOUS CHEMICAL LABORATORY FOR PRODUCING FOODSTUFFS FROM WATER AND CARBON DIOXIDE.

to various parts of the body. The actual "burning" takes place in the various cells of the different tissues of the body. Read in this connection pages 402-406 of Unit Eleven.

The oxygen for the burning of the food comes from the air. It is taken in through the nose and mouth through the windpipe and bronchial tubes to the lungs. It passes through the walls of the tiny air sacs of the lungs into the blood where it is dissolved and carried to the cells. In the cells it unites with the dissolved food materials. The carbon dioxide and some of the extra water formed are carried by the blood stream back to the lungs where these substances are breathed out as waste materials.

Plants breathe by a process similar to that of animals. The organs differ, however. The breathing apparatus is in the leaves. The oxygen and food materials are dissolved in water in the sap of the plant and carried to the various plant parts. The waste products are water and carbon dioxide just as in animals.

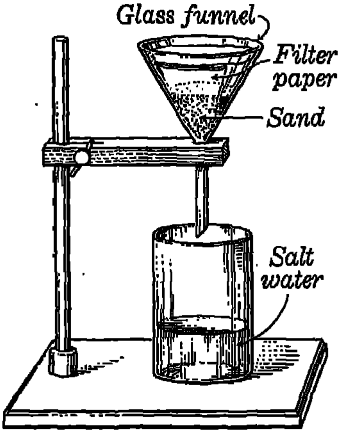
The manufacture of foodstuffs for the world goes on in the green parts of plants, for the most part in green leaves. Carbon dioxide from the air, part of which comes from the waste breathed out by people, plants, and animals, is taken into the leaves of the green plants. Water is taken up from soil water through the roots of these plants and carried in the sap to the leaves. In the leaf cells, where a green coloring matter called *chlorophyll* is found, this water and the carbon dioxide are combined into starches and sugars. (See page 237.) The energy for this manufacture comes from sunlight. The process goes on only in sunlight. The starches and sugars are stored in different parts of the plant and serve to supply the plant with needed food. Animals get their starches and sugars from these stored plant-foods. Such foods, as the starches in grains, the starch of the potato, and the sugars and starches of fruits like apples and pears are illustrations.

### 7. Why do we need water?

If plants and animals depend upon starches and sugars manufactured by the green plants for their food, then one of the most important raw materials for our food supply is water. In a very real sense we not only drink water, but we also eat it.

When you recall the story on pages 113-114, you can see that we depend upon water for our food supply in another way. Food materials to be taken up by the cells and tissues of our bodies must be dissolved in water. Sometimes we say that these foods must be in *solution.*

You can get some notion of what happens when a substance dissolves in water if you will repeat the first experiment suggested in this unit. *Stir a teaspoonful of common salt into a half glass of water. Taste the water before and after putting the salt into it. The salt seems to have disappeared, and yet the water tastes like salt. You cannot tell by looking at the water that there is salt in it. If you will boil the salt water in an evaporating dish until the water disappears, you can recover the salt in the bottom of the vessel. Taste the salt left in the dish. As a matter of fact, you can collect the steam from the water and condense it, and get water again without any salt in it. Can you carry out this last step?*



FILTER A MIXTURE OF SAND, SALT, AND WATER. WHY DOESN'T THE FILTER REMOVE THE SALT? HOW CAN YOU SEPARATE THE SALT AND WATER?

If you keep on adding salt to a salt solution, after a time you will reach a point where no more salt will dissolve. The extra salt will settle to the bottom of the container. When the water reaches the point, called the saturation point, where it will dissolve no more of a certain substance, we say that we have a *saturated solution* of that particular substance.

Although the salt in a solution seems to disappear, it does not form a compound. We can still recover the salt as salt, and the water as water. There is no new substance formed.

Neither is a solution a mixture in the ordinary sense. Water and mud, or water and sand, are mixtures, but not solutions. Some mixtures of solids with water can be separated from the water by filtering. A solution in water passes through a filter.

*Try making a mixture of sand and water. Now pour this mixture into a filter paper set into the mouth of a glass funnel. (Your teacher will show you how to fold a filter paper to fit the funnel.) Catch the water in a glass or beaker as it comes through the funnel. Note that it is clear and that the sand stays in the filter. What property of a mixture does this illustrate?*

*Now make a solution of salt in water. Taste the salt water. Pour this through a fresh filter paper and catch the water as it comes through. Taste this water. Does it taste salty? Is there any salt left in the filter paper?*

Many substances will dissolve in water. Some will not. Sugar dissolves in water, but starch does not. You can try this for yourself if you like. Some kinds of sugars are readily used by the human body as food. Starches must be changed into sugars to be used in the body. Since starches are not dissolved in water, they cannot be carried by the blood stream to different parts of the body. The starch is changed by chemicals in the digestive juices. We call these chemicals *enzymes.* The purpose of the enzymes is to change insoluble chemical compounds into new compounds that will dissolve in water.

The first of the enzymes to change starchy foods is found in the saliva in the mouth. Other digestive juices contain chemicals that form compounds of other kinds of foods, such as fats and proteins, so that these can dissolve in water.

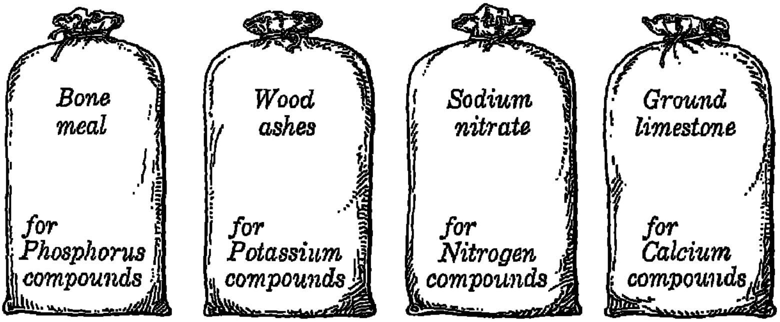
A process very much like the digestive changes that take place in the digestive tract occurs in the ripening of fruit. A green fruit contains a relatively large amount of starch.

Enzymes in the fruit change the starch into sugars, part of which are dissolved in the watery juices of the fruit. You can often tell when this ripening has taken place because the fruit tastes sweet, and because it is softer and juicier, due to the fact that some of the sugar from the changed starch is dissolved in the juice.

Water also carries the mineral foods needed by living plants. These mineral foods are found as compounds of the needed substances in the soil. (See pages 59-60.) The most needed of these are potassium, phosphorus, and nitrogen. Some others are calcium, sulphur, and magnesium. The compounds of these elements to be of value to plants must be dissolved in water to pass through the walls of the roots and flow through the plant tissues.

A plant suffers for lack of water in dry weather. It also suffers for lack of mineral foods, as these foods cannot be carried to the plant if the soil is extremely dry.

It is especially important that fertilizers used as plant foods contain compounds of these needed elements that will dissolve in water. If the fertilizing compounds do not dissolve, they cannot be of any value to the plants. You may be interested to see if commonly sold commercial fertilizers will dissolve in water.


Bone meal for Phosphorus compounds
Wood ashes for Potassium compounds
Sodium nitrate for Nitrogen compounds
Ground limestone for Calcium compounds

TO BE OF VALUE TO PLANTS, PLANT FERTILIZERS MUST DISSOLVE IN WATER.

Some fertilizers act very slowly. This means that when mixed with soil and exposed to the weather the contents of the fertilizer form new compounds that finally will dissolve in water. This is true of a fertilizer like bone meal. Little of the bone meal as it comes from the packing house will dissolve. For this reason it is not a good fertilizer to get quick results. Left on the soil and exposed to the elements in the soil and air, the bone meal changes slowly to other compounds that do dissolve and that can be used by plants.

## 8. Of what are we made?

From what we have said you must have seen that at any one time a considerable part of most plants, or of animal bodies, consists of water. This is true of our own bodies as well.

Much of the remaining weight is due to the weight of the bony structure. Bones are largely compounds of calcium and phosphorus. Calcium is the white mineral element which is the important element in lime, or in limestone. Older scientists said at one time that bones were made largely of lime.

Phosphorus occurs as an element in two forms. White phosphorus is a white waxy substance which is very poisonous. It catches fire readily when exposed to air at fairly low temperatures. Red phosphorus is a dull red powder. It is not poisonous and does not burn so readily when exposed to the air. Matches are tipped with a phosphorus compound which bursts into flame from the heat made by rubbing the match on some surface. The first phosphorus was prepared from animal bones. Phosphorus compounds are necessary fertilizers for most plants.

The material of the living cells and tissues of the more flexible parts of the body are mostly protein compounds. The source of the protein in your own body is from such foods as milk, eggs, lean meat, fish and from some kinds of vegetables, such as beans, and peas, and parts of the grains.

Small amounts of minerals also are found inside the cells of the body and in the blood stream. Some of these are iron, iodine, magnesium, and sodium. These are taken into the body in the vegetables which we eat. Common table salt is a compound of sodium and chlorine. This is a source of sodium for the body. Small amounts of iodine are taken from sea foods. It is probable that this is taken up by the sea animals from the sea water.

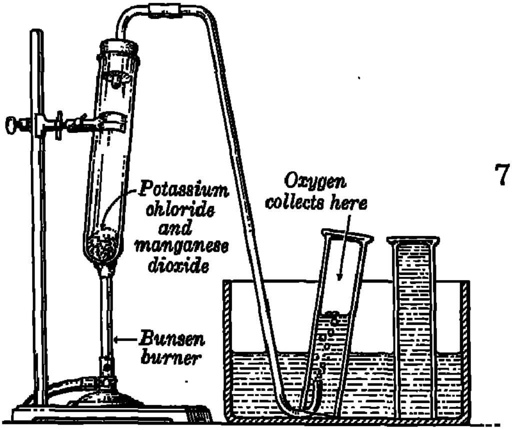
Our scientists have been able to find out many things about the composition of our bodies. This is useful in helping us to know the kinds of foods to eat for different purposes: starches and sugar, and fats for energy to work on; proteins for growth and tissue building; calcium-containing foods to make bones and teeth; and green vegetables for needed minerals. We can also get a better idea of the value of water and of the air we breathe. In spite of all this no one knows why a combination of chemical elements into some special compounds will make a living thing.

## THINGS TO DO

1. Make a list of ten substances that are solids. Which of these can be changed to liquids or gases? Make a list of five liquids. Which of these can be changed to solids? Can you tell how this can be done for one of the liquids? Make a list of five gases. Tell how one of these can be made into a liquid.
2. Describe the properties that determine whether or not a substance is a solid, a liquid, or a gas.
3. If you will mix some potassium chlorate with a small amount of manganese dioxide and then heat the mixture in a hard-glass test tube you can get free oxygen.

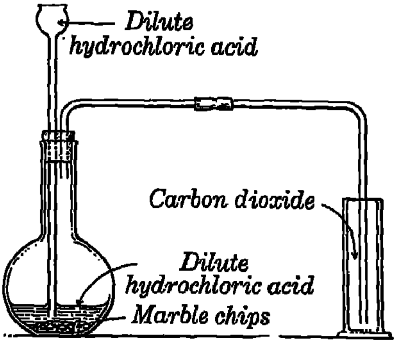
You have probably done this in your study of the air. The oxygen can be collected in a bottle as shown in the diagram. Light a splinter of soft wood. Blow out the blaze and dip the glowing splinter into a bottle of oxygen. What happens? Heat the end of a piece of iron wire until it is red hot. Plunge the glowing iron into a bottle of oxygen. What happens?

4. You can prepare the gas, carbon dioxide, by treating some bits of broken marble with dilute hydrochloric acid. Use a generator like that shown in the diagram. Collect some of the gas and test it with limewater. What happens? Treat some baking soda with strong vinegar. Collect some of the gas. Test the gas with limewater. What is the gas? Thrust a burning splinter into a bottle of the gas. What happens?
5. Find some samples of plant fertilizers. What parts of these will dissolve in water? How can you prove that any part of a sample of fertilizer has dissolved in water?
6. Try dissolving starch in water. How can you tell whether or not any starch has gone into solution in the water? Prove your point.
7. Dissolve sugar in water. How can you separate the dissolved sugar from the water? Try it. Is a solution of sugar in water liquid sugar? What is liquid sugar?



AN APPARATUS SIMILAR TO THIS CAN BE USED FOR GENERATING AND COLLECTING OXYGEN.

SOME THINGS TO REMEMBER



USE AN APPARATUS OF THIS TYPE FOR GENERATING CARBON DIOXIDE.

1. All substances exist in one of three states, as solids, liquids, or gases.
2. Many substances can be changed from one state to another and still remain the same substances.
3. Changes in temperature and pressure are important factors in changing a substance from one state to another.
4. Chemical elements are those elementary substances that cannot be separated into other simpler substances that have definite properties of their own.
5. There are 92 known chemical elements in the earth.
6. Elements are composed of very minute particles called atoms. Atoms are made of still smaller particles of electrical energy called protons and electrons.
7. A chemical compound is a substance which always consists of exactly the same chemical elements in the same proportions. The smallest particle of a compound is called a *molecule*.
8. A mixture of substances may consist of elements, of compounds, or of elements and compounds. A mixture may have different substances in different proportions at different times and places.
9. Pure water is a compound.
10. Water as we find it in nature is usually a mixture.
11. Air is a mixture.
12. Most of the common fuels consist of compounds of the elements carbon and hydrogen.
13. When a fuel burns it combines with oxygen to form new compounds. The oxygen for burning comes from the air.

14. The foods "burned" in our bodies to produce energy and heat are starches, sugars, and fats. These are compounds of carbon, oxygen, and hydrogen.
15. The foodstuffs of the world are manufactured by the green plants. The raw materials are carbon dioxide and water.
16. To be used by the tissues of the body, foods must be in solution in water.
17. The process of digestion changes food compounds into compounds that can be dissolved in water.
18. Mineral foods for plants must be dissolved in water to be used by the plants.
19. The human body consists of compounds of the chemical elements found elsewhere on earth.
20. No one knows just what makes a living substance out of chemical compounds.

### BOOKS TO READ

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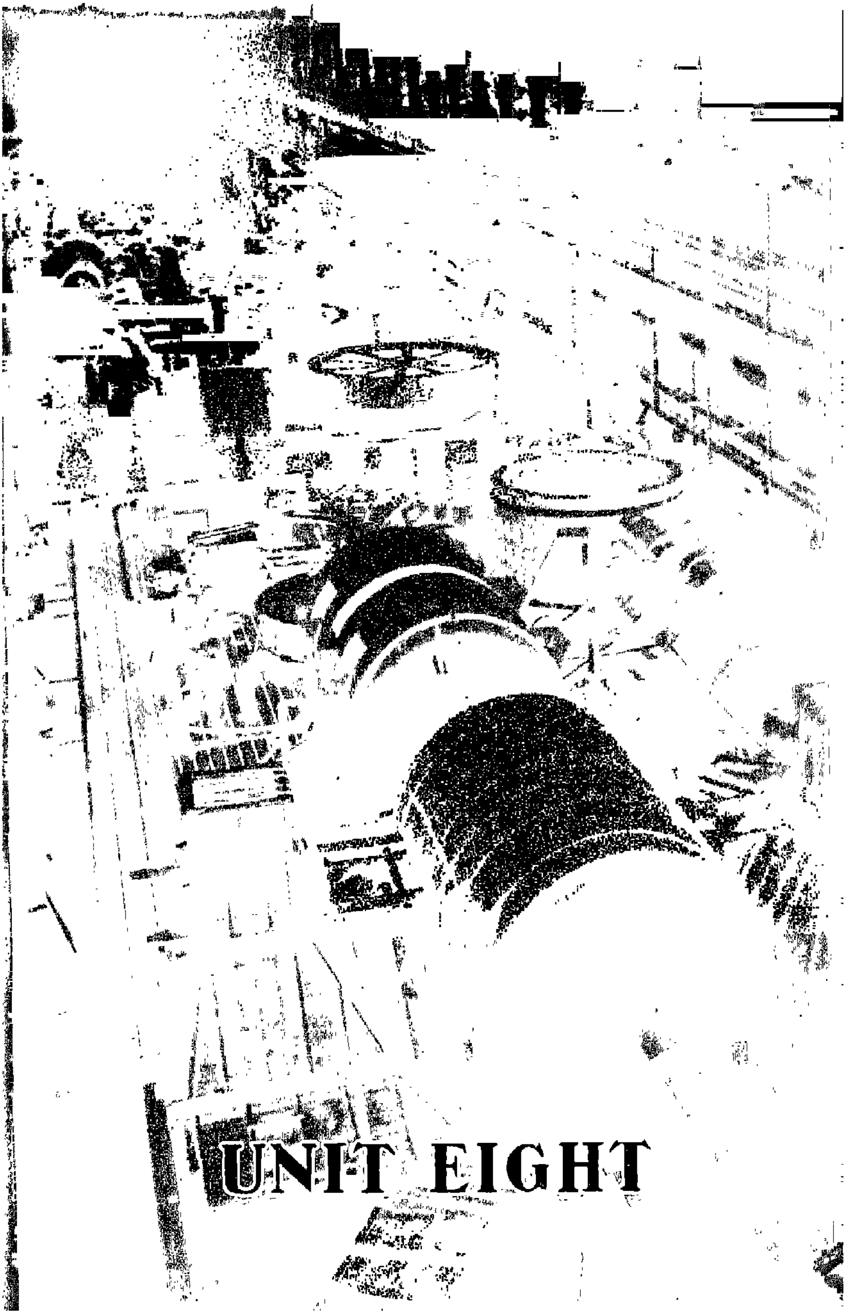


# UNIT EIGHT

## UNIT EIGHT

# How We Use Machines to Do Work

### WHAT THIS UNIT IS ABOUT

Look about you and see how many of the things that you do almost every minute of your day are accomplished by means of tools or machines. Did you walk to school this morning, or did you ride? How many people in your science class ride bicycles? How many roller skate? How is your food brought to the kitchen door? How are the tears in your clothing mended? If your father is a business man, how are his letters written? These are just some of the things for which we depend upon machines.

*Suppose that you take a pencil and sheet of paper and list all of the things you can find about your home that you would call machines. How many can you find in half an hour? Do not forget such things as door hinges, locks, pulleys and cords on windows, such kitchen equipment as the egg beater and can opener, the fire tongs, nutcracker, food grinder, sewing machine, and the family typewriter.*

How many of the things for making labor more efficient at home use wheels of one kind or another? What is the value of a wheel in each of these machines?

Of what value are gears in machines? Have you ever torn down an old alarm clock. Why are the wheels of different sizes? Can you explain why some of the wheels run faster than others? Why does the driver need to shift gears in driving an automobile? Can you explain why shifting gears seems to change the speed at which a car moves?

Many household machines need to have good care. Do you know how to keep the machines at home in good order. Often machines need to be oiled. Do you know why machines need oiling? How can you find out where to oil a machine?

In what ways are these everyday machines of use to you? Can you make a list of advantages which these machines have for you. One way to see this is to think of your life without the machines which you have in your home. Are you more safe or less safe with machines than without them? What do you do with the time that can be saved by the use of machines? Do machines save your family money? Is it possible that you could get along very well without some of the machines which you have and so save considerable money? Do you have a food mixer in the kitchen? Is it worth what it costs?

In this unit we shall try to understand the machines with which we live every day. We shall try to get a better notion of how some of them work. We shall try to get a better idea of just what each machine or tool can do for us. We shall also try to see how we can make our uses of machines safer. Perhaps we can get better notions of those machines that are of real use and those without which we can easily get along. What is the difference between a useful tool and a "gadget"?

# How We Use Machines to Do Work

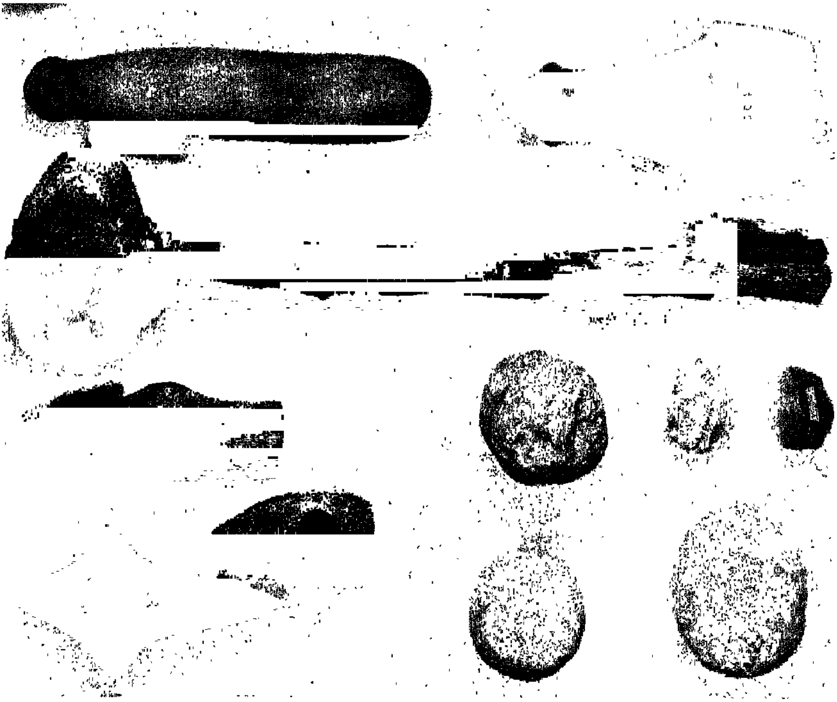
## UNIT PROBLEMS

1. How can we do work without tools?
2. How can simple tools be used to help us in doing work?
3. What is a machine?
4. How are wheels used in machines?
5. How can friction in machines be reduced?
6. What kinds of work can be done with a screw?
7. How do gears improve machines?
8. How can we avoid injuries from machines?
9. What sources of power can be used to drive machines?
10. Which costs more, man power or machine power?

### 1. How can we do work without tools?

We are so accustomed to doing our daily work with all kinds of tools and machines that we seldom ask how we could get along with even the simplest tasks if we had no such tools or machines. Do you remember watching the family dog dig a hole in the ground? Perhaps as a child you have made similar holes in a sand pile just with your hands. But if you want a larger hole in firmer earth you immediately say, "I must have a shovel." Now what does the shovel add to the use of the hands?

If we dig a hole in the earth with a tool harder than the earth, we save the skin on our hands. Sharpening the edge of the tool so that it goes into the earth more readily makes

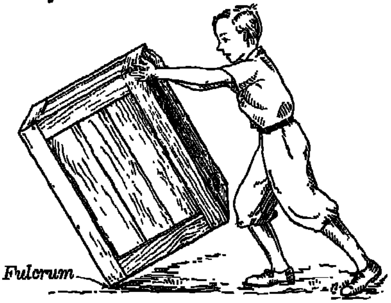


HAND TOOLS OF ANCIENT TIMES WERE VERY DIFFERENT FROM THE MODERN ONES IN USE TODAY.

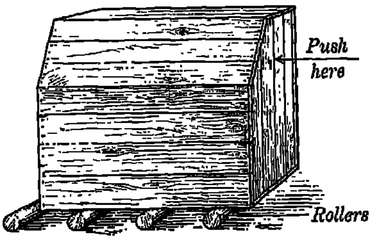
a better tool for the purpose. A sharp stick or a piece of flat stone could be used. Indeed, early men used such tools for digging in the earth. If you have an opportunity to visit a museum you can see some of these. You should look first at the earliest tools, and then, as you go along, examine tool improvements as to handle, sharpness, and structure. Shaping the digging tool so that more earth can be moved with it at each stroke makes it possible to finish a given amount of work in a shorter time. If we add a handle to the tool, we can work from a more comfortable position. The handle can also be used to give some *leverage* against the earth to be moved.

Another common experience that we have all tried without tools is that of lifting or moving a heavy object. With bare hands it is often very difficult to grasp or to get hold of the thing to be moved. This is true of a heavy box, such as a box of books or a case of canned vegetables. Sometimes if we cannot lift a box we can push against an upper edge and turn it over. In this way we do not have to lift all of the weight of the box at one time. A box does not roll well and the bumpy rolling may damage the contents, but a box can sometimes be moved in this way. A heavy barrel can often be moved more readily than a box of the same weight because the barrel can be rolled.

Another way to move a weight is to drag it. In this process we not only work against the resistance of the weight of the object but also against the thing we call *friction*, the resistance due to the rubbing of the box on the ground or floor. One way to reduce the friction is to cut down the areas of the surfaces that rub or drag. This can be done with runners, as with a sled. Often stone boats are used for moving heavy stones from fields. A stone boat is a crude, heavy sled. Rollers usually work better than runners. Why? Often in moving very heavy objects, round poles or rollers are pushed under the front edge to reduce the friction in dragging the weight.



YOU CAN MOVE A HEAVY BOX BY PUSHING AGAINST AN UPPER EDGE.

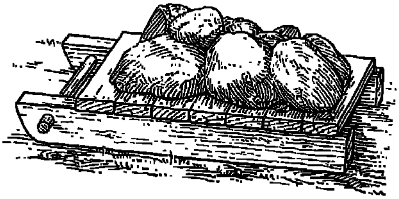


FRICTION IN MOVING HEAVY WEIGHTS CAN BE REDUCED BY USING ROLLERS.

Sometimes, if an object cannot be lifted up to where we want it, an inclined board can be put from the place where the weight is to be lifted to the ground and our box or bale dragged up the slope. You have seen this in gangplanks for ships and in loading chutes for trucks. It is supposed that the great stones for the Pyramids were raised in place in this way; that is, by means of rollers on an inclined plane.

*Arrange for a committee of boys from the class to visit a garage in the neighborhood to observe the uses of all of the tools used in the garage for lifting heavy weights. Ask the boys to make a list of these tools and to make diagrams. Have the committee make a report to the class and explain these machines with blackboard diagrams, or possibly with demonstrations of some of them.*

We also do work in moving ourselves from place to place. If you now get up out of your chair and stand, you have done work in raising the weight of your own body out of the chair. If you walk across the room you do work in moving the weight of your body across the distance through which you have walked.



RUNNERS SERVE TO REDUCE FRICTION IN DRAGGING HEAVY OBJECTS.

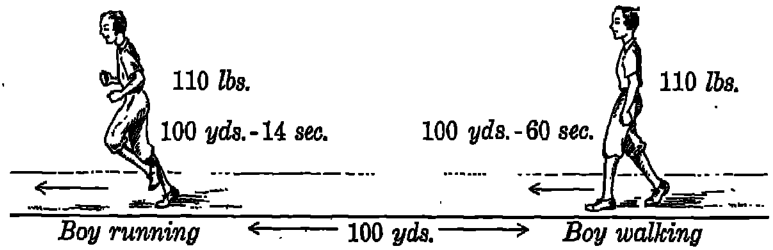
If two people walk a distance of twenty feet, the person weighing the more will have done the more work. If one weighs 150 pounds and the other 110 pounds, the person weighing 150 pounds does the more work in walking a given distance. If two people weighing the same amount, perhaps 120 pounds, walk different distances, the person walking the farther does the more work. For example, suppose these two people walk home from school. One lives half a mile from school and the other three quarters of a mile. The one living three quarters of a mile from school will do the more work in walking home.

In going up stairs the amount of work that you do is determined by the weight of your body and the vertical distance from floor to floor through which you lift your weight. The length of the slope of the stair does not determine the amount of work done. If you weigh 100 pounds and the distance up from the first to the second floor is 10 feet, the amount of work that you do in going upstairs is 10 x 100. We call this figure the number of *foot-pounds* of work done. It does not matter if the slope of the stair is 20 or 30 feet long.

*Make a chart showing how much work in foot-pounds is done by each member of your class in going from the first to the second floor in your school.*

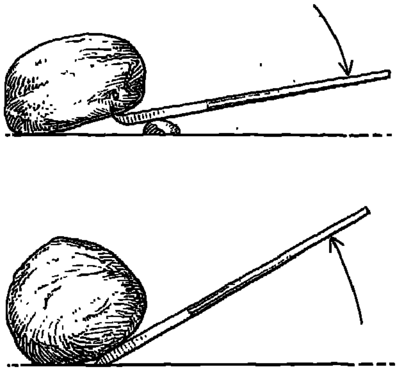
It seems easier to go upstairs by means of a stairway than to climb up a ladder. It seems easier if the slope of the stair is long rather than short. This is because your weight is lifted through a shorter distance at any one moment. Actually to get your weight up 10 feet requires approximately the same amount of work in any of these cases.

Here are some simple problems about work. If you carry a baby brother who weighs 20 pounds upstairs, how much more work do you do than if you went up empty-handed, if the second floor is 10 feet above the first? If a housewife is 20 pounds overweight, how much extra work does she do every time she goes upstairs in a house where the second


110 *lbs.*
100 *yds.*-14 *sec.*
100 *yds.*-60 *sec.*
110 *lbs.*
*Boy running*
100 *yds.*
*Boy walking*

WHICH BOY DOES MORE WORK IN TRAVELING 100 YARDS?

floor is 12 feet above the first floor? A boy who holds the record on a track team can run 100 yards in ten seconds. Does he do more work when he runs a race or when he takes ten minutes to walk leisurely 100 yards down the track? Explain your answer.



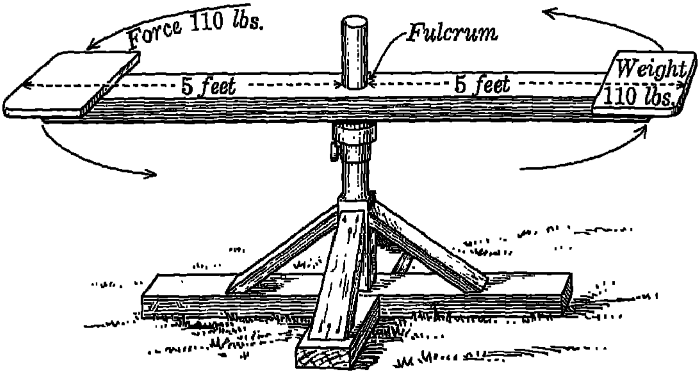
HERE ARE TWO WAYS IN WHICH A SIMPLE LEVER MAY BE USED TO MOVE A HEAVY STONE.

As soon as we work out some scheme to ride, we introduce the use of a machine, and determining the amount of work done is not always so simple. We can fasten runners to our feet as with ice skates. If the surface is smooth, we may be able to glide part of the way on our journey. Or we can put wheels on the skates and roll along. Perhaps we can arrange our wheels with a seat and sit down as we drive our weight along, as with a bicycle. In all of these cases we still use the energy developed in our own bodies, but we use relatively simple machines to make our work seem easier.

## 2. How can simple tools be used to help us in doing work?

Some simple tools can be used to make our work seem easier, or to make it possible for us to perform some tasks at all with the amount of energy that we can muster at any one time.

One such simple tool is the *lever*. In its simplest form this can be just a stout pole, or pipe, or a bar. Suppose that it is necessary to move a large stone that one person cannot lift. If a long stout pole can be found, it may be possible to move the stone. One end of the pole must be pushed under the



THE MECHANICAL ADVANTAGE OF A SIMPLE MERRY-GO-ROUND WITH EQUAL ARMS IS 1.

| | | | |
|---|---|---|---|
| TOTAL LENGTH OF LEVER | 10 FT. | WEIGHT | 110 LBS. |
| LENGTH OF WEIGHT ARM | 5 FT. | FORCE | 110 LBS. |
| LENGTH OF FORCE ARM | 5 FT. | MECHANICAL ADVANTAGE | 5/5, OR 1/1, OR 1 |

edge of the stone. A block is then put behind the pole on the side away from the stone. The worker pulls down or outward on the outer end of the pole. Thus he may be able to lift the edge of the stone with his pole. If he wishes to push the stone he can push the end of the pole in the ground and push against the stone by pulling on the outer end of the pole.

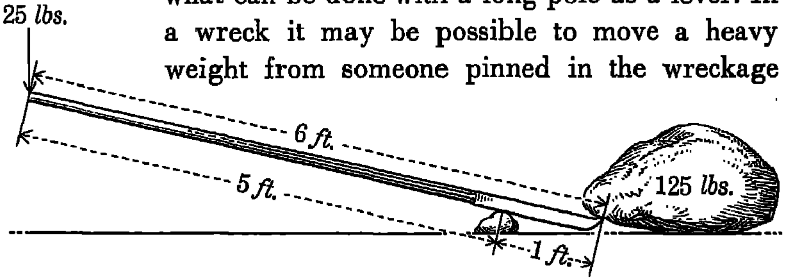
The point on the pole about which the motion turns is the pivot of the machine. Usually we call this the *fulcrum* of a lever. Suppose we call the length of the pole from the end against which the weight of the stone rests to the fulcrum, *the weight arm* of the lever, and the length from the end against which we pull or push to the fulcrum, *the force arm.*

The secret of the lever is in the difference in the lengths of these two arms. If the two arms are the same length there is no advantage, and we might just as well push directly against our stone with no pole. A child's simple merry-go-round with the pivot in the center is a lever with arms of equal length. A simple balance with the pivot in the center of the scale beam is also a lever with equal length arms.

Let us suppose that the pole which we use to move a stone is six feet long. Suppose that the distance from the end which rests against the stone to the fulcrum is one foot. Suppose the length of the force arm from the fulcrum to the other end of the pole is five feet. The advantage in this lever would then be five to one. If you are able to push with a force of 25 pounds against the end of the pole, you can move a weight of 125 pounds at the other end of the pole.

A common steel bar made to be used as a lever in rough work is called a crowbar. Some of these have the lower end sharpened to make it easier to get the bar under heavy objects. Some such bars have a slight crook near the lower end so that the heel of the bar serves as the fulcrum. Smaller bars are sold in hardware stores for general household use. These are called pinch bars, or wrecking bars. Most of these have the bend near the lower end, and a crook at the upper end like a shepherd's crook. This curved end is slotted and can be used as a lever for pulling nails.

It may be very useful in some emergency to remember what can be done with a long pole as a lever. In a wreck it may be possible to move a heavy weight from someone pinned in the wreckage



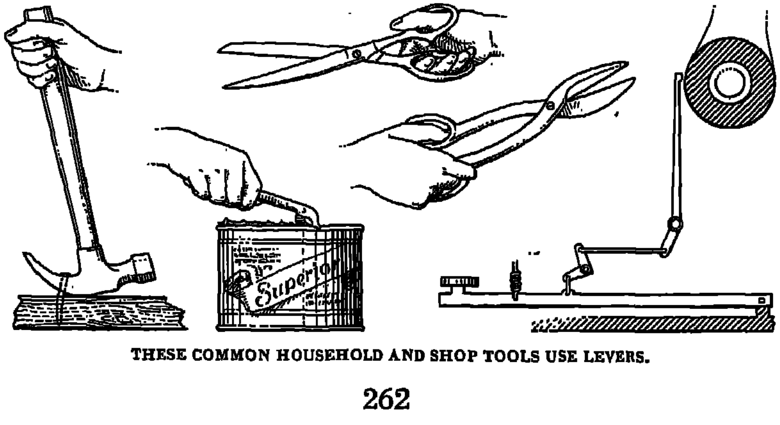
THE MECHANICAL ADVANTAGE OF A LEVER IS THE RATIO OF THE LENGTH OF THE FORCE ARM TO THE LENGTH OF THE WEIGHT ARM.

| | | | |
|---|---|---|---|
| TOTAL LENGTH OF LEVER | 6 FT. | WEIGHT | 125 LBS. |
| FORCE ARM | 5 FT. | FORCE | 25 LBS. |
| WEIGHT ARM | 1 FT. | MECHANICAL ADVANTAGE | 5/1 OR 5 |

with such a tool, or to lift a mired wheel with a pole under the hub. Can you name any other uses of a long pole as a lever?

How many of our simple household tools are levers or combinations of levers? The ordinary hammer is often used as a lever. When used for pulling nails, the fulcrum is at the point where the head touches the wood. The weight arm is the claw and the force arm the handle. The simplest kitchen can opener is another version of this tool. Any pair of shears is an illustration of a pair of levers with the fulcrum at the pivot in the shears. Note that the handle of the shears is longer in proportion to the blade for shears used for heavy work, such as the tinner's shears. Compare these with the paper hanger's shears. Any pair of pliers uses the same principle for a different purpose. *Look about you and see how many common tools use the lever principle. Arrange a temporary class exhibit of all of the simple household tools which operate as levers. Label each of these and indicate the fulcrum, the weight arm, and the force arm of the lever. Begin your collection with shears, hammer, can opener, and so on.*

Some of our more complicated machines contain interesting levers. *Examine a typewriter from beneath to see how a relatively light touch on a key makes a strong blow of the type bar. Where is the fulcrum in the lever of the typewriter*



THESE COMMON HOUSEHOLD AND SHOP TOOLS USE LEVERS.

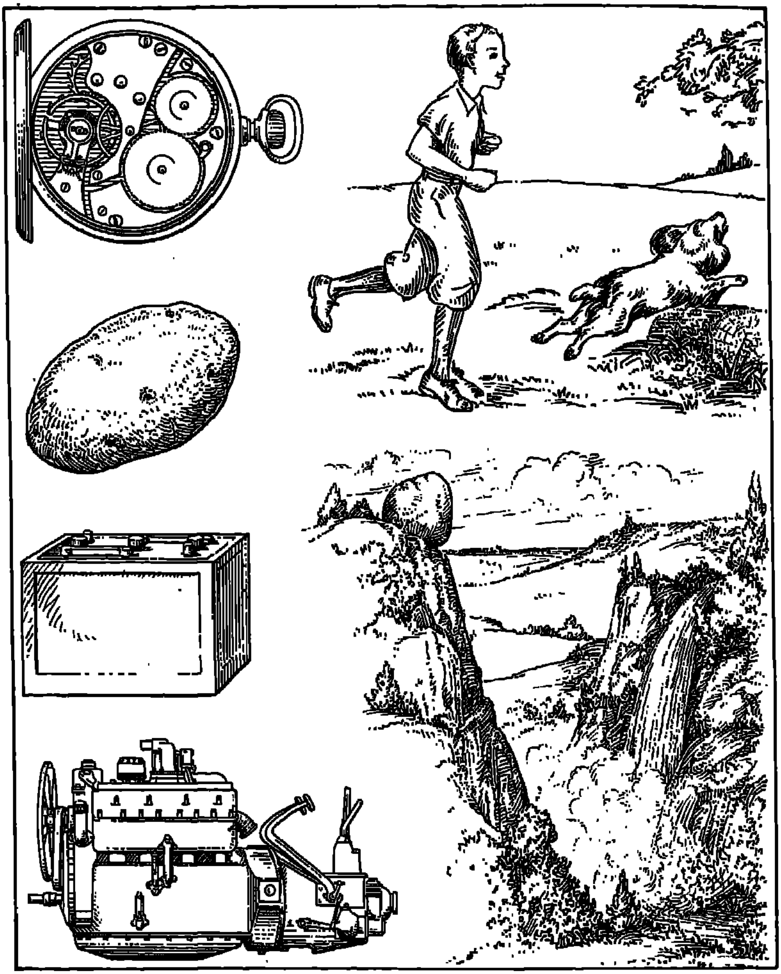
*key and type-bar lever? Which is the force arm and which is the weight arm? How many such levers are there in a standard typewriter? Ask the teacher to lift the front from a piano and allow you to look at the action. Can you draw a diagram of the lever system by means of which a pressure on a piano key makes a hammer strike a string in the piano?*

### 3. What is a machine?

The scientist says that we do *work* only when some force produces movement through some measurable distance. If a small boy pushes very hard against the side of the schoolhouse, he does no work since the building does not move. The scientist measures work by the result produced rather than by the amount of the effort expended. In the English system of measurement, work is measured by foot-pounds. This means that if a force of one pound moves a thing through a distance of one foot, a foot-pound of work is done. We find the amount of work in a particular situation by multiplying the force measured in pounds by the distance through which the movement takes place in feet. If you will remember our stairway problems, a girl weighing 90 pounds must exert a force of 90 pounds to raise her own weight one foot. If she goes up a stair a distance of 10 feet above the first floor she will do 900 foot-pounds of work.

We define *energy* as the capacity or ability to do work. If we go back to our definition of work, you will see that energy is the capacity to produce movement. The coiled spring in your watch has energy since it can produce movement in the wheels of the watch. Any one of your friends has energy since he can move through a distance, or make other things move. Your pet dog has energy; so does the running motor in the family automobile.

Some things that are not moving, but have the power of



THINGS THAT CAN PRODUCE MOVEMENT HAVE ENERGY.

producing movement, are also thought of as having energy. A potato has energy, since its starch when digested can furnish energy for movement in a human being. A rock poised on the edge of a cliff seems perfectly still. We say that it has energy, because it can produce much movement if it is pushed over the edge of the cliff and allowed to fall into the chasm below. Gasoline, coal, fuel oil, gunpowder, falling water, an electric cell, all have energy since they have the capacity to produce movement.

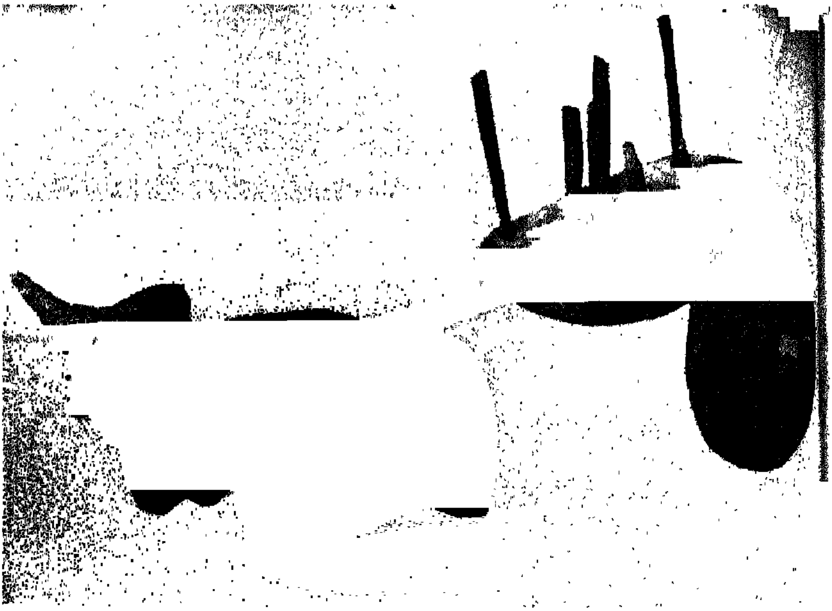
*Make a list of twenty things which have energy. Explain the form in which the energy is found in each of these.*

We have learned to make better use of the energy which we possess by using machines in doing work. Some of these machines we use to multiply the forces of energy which we can develop in our own bodies. Such machines are the simple lever, a wheelbarrow, a bicycle, a hammer, a block and tackle, an automobile jack. In other machines we have learned to control the energy stored up in water at some high level, in various kinds of fuel such as gasoline or coal, and in the reaction of different kinds of chemical substances, as in explosives. Some machines in which we make use of this stored-up energy are steam engines, electric generators and motors, and gasoline motors.

Any device or apparatus used for controlling energy in doing work is a machine. The machine may be as simple as the lever in a playground seesaw or it may be as complicated as the motor in the airplane which soars overhead as we look up from the playground.

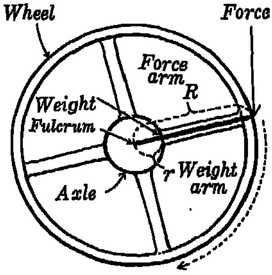
### 4. How are wheels used in machines?

This seems an absurd question to ask in our present world. Look around and see how many of the machines which you can find have wheels. Perhaps it would be simpler to try to find a machine that does not have a wheel. But there have been many generations of primitive men who lived for a great many years without ever discovering wheels. It is possible to get along without a wheel. What have we gained by learning to make and use wheels?



THIS VERY ANCIENT TOY INDICATES AN EARLY USE OF WHEELS IN INDIA ABOUT 5000 YEARS AGO.

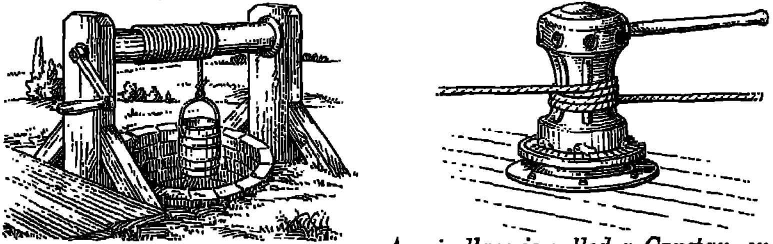
One advantage in placing a wheel under a load is in reducing what we call friction. Friction is the resistance which the surfaces of two objects have to being moved against one another. If a surface is rough, it offers more resistance than a smooth or polished surface. Usually a heavy object presses on its lower face until it produces more friction against the surface below than a light object would. A roller or wheel offers less surface for the drag of friction at any one time. A box three feet square offers nine square feet of surface as friction against the floor, if someone tries to drag it. If two rollers two inches in diameter are placed under this box, about how much surface offers resistance at any one time? If wheels are mounted under the box, the bearing surface at any one time is reduced to the parts of the wheels that touch the floor and the parts of the wheels that rest upon the axles.



THE ADVANTAGE IN THE LEVERAGE OF A WHEEL FIXED TO AN AXLE IS THE RATIO OF THE RADIUS OF THE WHEEL TO THE RADIUS OF THE AXLE.

The fact that a wheel rolls or turns adds to the advantage gained in reducing the bearing surface exposed to friction. In turning, the wheel acts as a lever with the fulcrum at the center. The length of the lever is the radius of the wheel, or the distance from the center to the rim. The advantage in the leverage of a wheel fixed to an axle is the relationship of the radius of the wheel to the radius of the axle. This relationship is expressed as a ratio, R/r. R is the radius of the wheel and r is the radius of the axle.

The advantage of a wheel and axle can be seen in such a simple device as a windlass. A windlass is an axle with a rope wound about it for raising weights. A crank or wheel is fastened to one end to turn the axle. The weight to be moved is fastened to the end of the rope. This device is often used for raising earth from excavations that are dug by hand. The advantage in lifting the bucket of earth is the ratio of the length of the crank arm to the radius of the axle about which the rope is wound. See the figure on this page. The crank arm represents the radius of a wheel. The same effect



*Windlass - Used to lift*

*A windlass is called a Capstan on board ship. Used to draw*

THE ADVANTAGE OF A WINDLASS IS THE RATIO OF THE LENGTH OF THE CRANK ARM TO THE RADIUS OF THE AXLE ABOUT WHICH THE ROPE IS WOUND.

would result from putting a wheel on the end of the windlass axle and putting a handle at some point on the rim of the wheel.

### 5. How can friction in machines be reduced?

You know, of course, that often it is necessary to stop at a service station to have oil put into the motor of the family automobile or, if you ride a bicycle, that it is necessary to keep the wheel bearings oiled. If you use a typewriter one of the things you do occasionally is to oil the machine. The purpose of the oil in these machines is to make the surfaces that work on one another slip more readily. It is to make the bearing surfaces smoother. Or, it is to reduce friction in the machines.

The part of a machine upon which a moving part bears or works is called a bearing. It is in the bearing that friction must be overcome. If the part turns with difficulty the efficiency of the machine will be cut down. Machines wear out first in the bearings. Keeping the bearing smooth and oiled reduces the wear in the machine. Very often a part that turns with difficulty produces heat in the bearing. Metal bearings expand with heat and sometimes the expansion is enough to keep the part from turning. Curiously, the machinist says that such a bearing that has stuck from overheating is frozen.

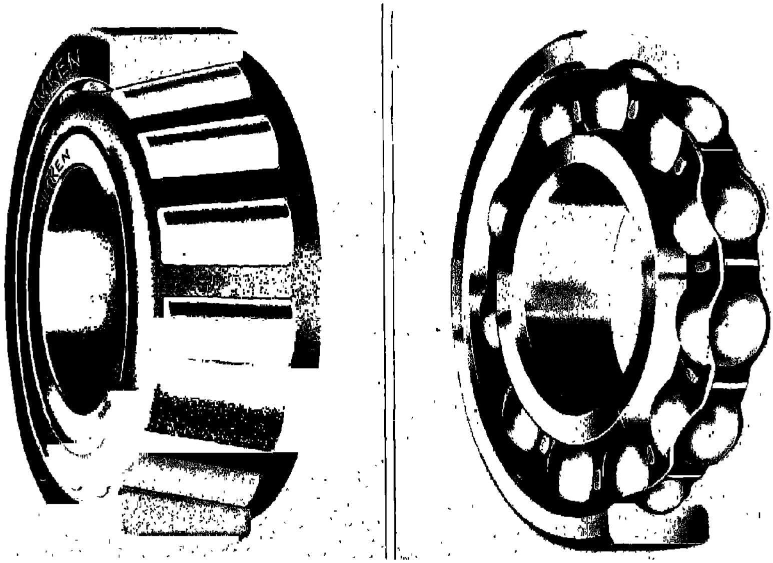
There are other ways to reduce friction in bearings besides using oil to smooth the surfaces. One way is to reduce the size of the bearing parts. In some machines the axle of a wheel spins in the bearing very much like the spindle of a top. You can see this arrangement in some watch and clock bearings. Another way to reduce friction is to make the bearings of some very hard, smooth substance. In fine watches the bearings in which the wheel axles turn are made of hard, polished jewels. It is for this reason that you hear the expression a

15-jeweled, or 17-jeweled watch. The jewels are the bearings for the more important moving parts. Some of the fine fishermen's reels have jeweled bearings. The finest balances for weighing chemicals have agate or quartz bearings.

*Examine some machine which you have in your home. What means are used to overcome friction in this machine? Where should it be oiled? How often? Does the operation of the machine depend upon the use of friction at some point in it? Where and how?*

In nearly all machines with rapidly moving wheels, the inside of the wheel bearing where it turns about the axle is lined with a special bearing metal that can be made very much smoother than the substance of which the wheel is made. Wooden wheels have metal bearings inside the hubs. Often the bearings of steel wheels are made of softer metals that can be replaced when the bearings become worn. These bearings are usually made of alloys of metals especially designed for bearings. *If you will examine the lining of an electric motor or fan where the axle comes through the motor frame,*

ROLLER AND BALL BEARINGS CUT DOWN THE BEARING SURFACE AND, THEREFORE, LESSEN THE FRICTION.



EXAMINE THE TREADS ON THE SOLES OF THE SHOES OF A BASKETBALL PLAYER.

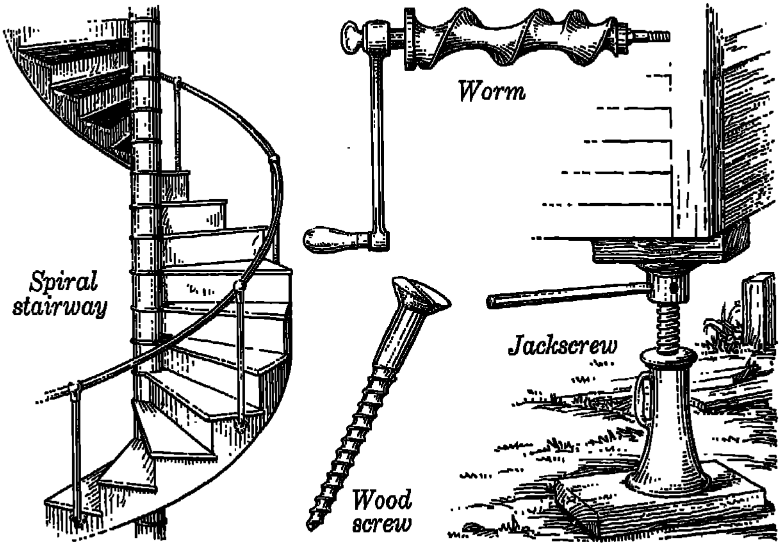
*you will be able to see the bearing lining and probably see that it is made of a different metal from that of the frame or the axle.*

Many of our machines have especially made bearings in which rollers or small steel balls are placed in a ring around the axle inside the wheel bearing. These are called either roller or ball bearings. They serve to reduce the amount of bearing metal that touches at any one moment and give space for the circulation of oil about the bearing. Bicycle wheels usually have ball bearings. Automobile wheel hubs often contain roller bearings. Perhaps you can get an old bearing cage containing roller or ball bearings from an automobile wrecking company.

Not all friction in machines is undesirable. Much of our work is possible because of friction. In order to walk it is necessary that the soles of our shoes have some friction against the floor. If a floor has been waxed too smoothly, someone may fall down for lack of enough friction. Automobiles are driven by means of the friction of the rear wheels with the pavement. The treads on the tires have special markings and groovings to increase friction with the pavement. When streets are icy, chains are added for increased traction. Basketball players wear shoes with heavy rubber soles to make more friction with the floor. Can you think of other cases where friction is an advantage rather than a disadvantage?

### 6. What kinds of work can be done with a screw?

The screw produces the greatest power for the amount of force applied to it of any of our simple machines. Illustrations of the use of the screw principle are found in ordinary wood screws, all bolts and nuts, the common jackscrew, the



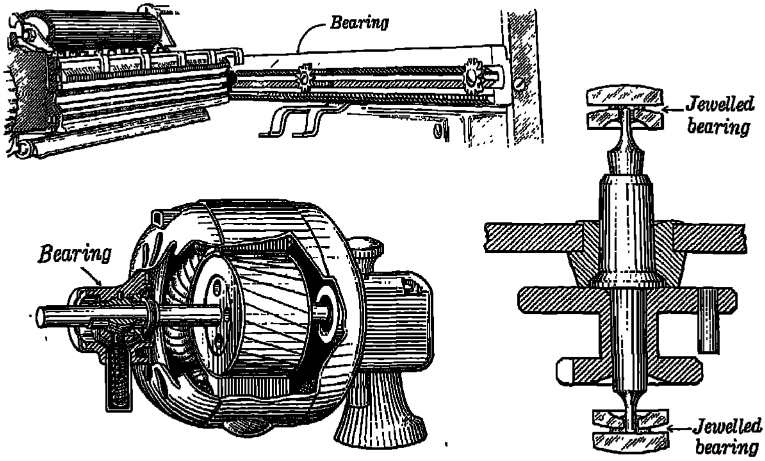
THE SCREW IS A COMBINATION OF THE INCLINED PLANE AND THE LEVER.

automobile jack, the screw-type nutcracker, the "worm" of the food chopper, worm gears and machine bolts in cars.

In reality, a screw is a combination of two of our other machines, the inclined plane and the lever, or crank. You will remember the advantage of the ordinary stairway, or the loading skids for a truck, where the weight is moved along the slope for some distance in order to gain a smaller rise in lifting the weight up from the level on which it starts. By using a relatively small force to move the load along the slope the heavy load can bo slowly moved through the upward distance which it has to travel.

In effect, a spiral or winding stairway is a giant screw. In any screw, an inclined plane winds around the center. For an ordinary screw we say that it is threaded. Sometimes the winding inclined plane (between the grooves) is called the lands on the screw. In nearly all screws we add at one end a lever which turns the screw. The added advantage due to the lever increases with the length of the lever from the center of the screw out to the point on the lever where the force is applied. In an ordinary wood screw the leverage is increased by making a head which is larger than the body of the screw. The radius of the handle of the screw driver determines the length of the lever. Increased leverage is obtained with a common bolt because the force is applied to the nut. In this case the advantage is determined by the length of the wrench which serves as the lever or crank to turn the nut.

*Examine a jackscrew of the kind used to raise buildings or bridges. How long is the lever used to turn the head? How much does the top of the screw rise for each complete turn of the screw? Would the advantage be increased or reduced if the pitch of the screw were changed to make it necessary to turn the screw oftener for the same gain in height? Examine the worm and crank in any ordinary food chopper.*

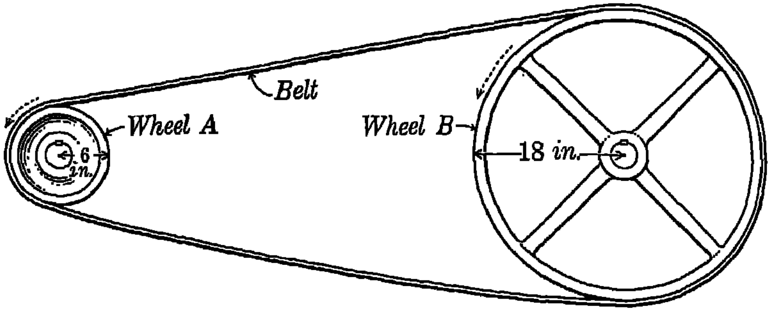


BEARINGS ARE USED IN MANY FAMILIAR MACHINES. A JEWELED WATCH BEARING, A BEARING IN AN ELECTRIC MOTOR, AND A SLIDING BEARING IN A TYPEWRITER ARE EXAMPLES. WHERE WOULD YOU OIL THESE?

### 7. How do gears improve machines?

Many of our machines that are made up of systems of wheels contain gears. Gears are simply toothed wheels so arranged that the teeth on one wheel fit into the teeth on another wheel so that turning one also turns the other.

It is possible to turn one wheel from another without putting teeth on either wheel. The wheels can be so placed that the faces of the wheels will rub and the friction due to pressure of one on the other moves the second wheel. This scheme is used in the clutch of some automobiles to make it possible to disengage the turning flywheel of the motor from the parts which drive the car. In the clutch the heavy springs which hold the faces of the wheels together give friction enough to keep the plates from slipping. When the clutch is disengaged, a lever compresses the spring so that the plates are held apart. This lets the motor turn without driving the car.



THE RATIO OF WHEEL B TO WHEEL A IS 18/6, OR 3/1. IF POWER IS APPLIED TO A, IT WILL TURN ROUND 3 TIMES TO MAKE B TURN ONCE. IF POWER IS APPLIED TO B, A WILL TURN 3 TIMES FOR EACH REVOLUTION OF B.

Belts are also used to drive one wheel from another. Two kinds of belts are used. A flat belt runs over a flat outer rim on the wheel. A round or V-shaped belt runs in a grooved rim on the wheel. The friction of the belt on the wheels serves to turn the second wheel. If the belt slips there is much loss of power between the two wheels.

With a belt system, if the two wheels are the same size, the wheel that is driven turns at the same speed and with approximately the same force as the power wheel. The only advantage is that by means of the belt it is possible to transmit energy from the machine furnishing the power to another machine or to some other part of the same machine.

In most machines the wheels are not the same size. When this is true, the two wheels do not turn at the same speed. If the driving wheel is large and the driven wheel is small, the small wheel will run at greater speed than the driving wheel. If the driving wheel is small and the driven wheel is large, the driven wheel will turn more slowly. The difference in the speed of the two wheels in either case will be in proportion to the ratios of the radii of the two wheels.

If a driving wheel is twelve inches in diameter and the wheel driven by it is six inches, the ratio of the radii is 6:3. In this case the small wheel will turn twice for every revolution of the big wheel.

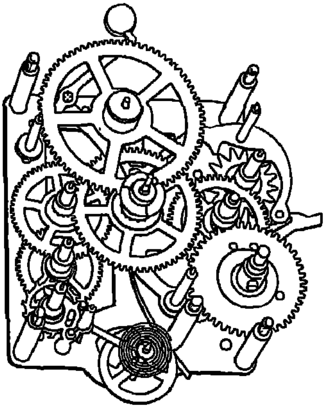
If it is desirable that the machinery run more rapidly as compared with the source of the power, the driving wheel is made large and the wheel driven by it is made small. *You can see this by examining a foot-driven sewing machine, or an old-fashioned spinning wheel. Turn the drive wheel around slowly once. Count the number of times the smaller wheel connected to it by the belt turns.*

If we wish to increase the force from the driving wheel, this can be done by having it turn several times for each revolution of a larger driven wheel. This holds to our principle that a force may be moved through a greater distance in order to multiply the force used in moving the load through a shorter distance. With a wheel-and-belt system this is accomplished by making the driving wheel quite small and the driven wheel large. In this way the driving wheel turns over several times to every turn of the other wheel. The opposite of this is true in a bicycle. *You can see this by comparing the sprocket wheel and the rear wheel of a bicycle. How many times does the sprocket wheel have to turn for each complete revolution of the rear wheel? If you can examine the power unit of a mechanical refrigerator driven by a belt you will find the pulley wheel on the motor small and the wheel on the compressor quite large by comparison.*

Friction drives and belts often cause trouble in machinery. Friction drives often slip. Belts slip and break. A belt system takes up much room and it is difficult to fit a system of belt-driven wheels into a compact space. Geared wheels work better and can be built to fit into a very small space. *Note the size of our present-day wrist watches.*

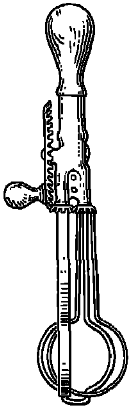
The principle of the relationship of geared wheels is the same as that for belt-driven wheels. If two geared wheels are the same size, they will turn at the same rate and give approximately the same power. If the driving wheel is larger it will turn more slowly than the small wheel driven by it. If the driving wheel is smaller, it will turn more often than the larger wheel driven by it and the force will be multiplied. The ratio can be found by comparing the radii of the two wheels. For gears, the teeth are evenly distributed around the circumference of the wheels. The ratio of the two wheels can be compared by counting the teeth on the two wheels to be compared. If the driving wheel in a gear system has 48 teeth and the driven wheel twelve teeth, the ratio of the two is 48:12. The small wheel will turn four times for each revolution of the driving wheel.

*You can check this with an ordinary ten-cent-store egg beater. If it is of the twin-beater type, use the small gear on one of the beaters. Make a mark on one of the teeth of the large wheel and on the small wheel which turns the beater. Count the teeth on each. What is the ratio of the two wheels? Turn the crank and count the number of times the small wheel goes around for each turn of the large wheel. How does this compare with the ratio of the number of teeth in the two wheels? If you turn the beater instead of the crank, how many times do you have to turn the beater wheel to turn the crank wheel around once? What is the increase in force gained by turning the small wheel?*



THIS DRAWING SHOWS THE GEARING OF A SIMPLE CLOCK.

*After inspecting the gear systems of some simple machines, such as the egg beater, a cheap alarm clock, or an inexpensive fisherman's reel, can you tell what the difference in gearing between the high gear and the low gear in an automobile transmission should be?*



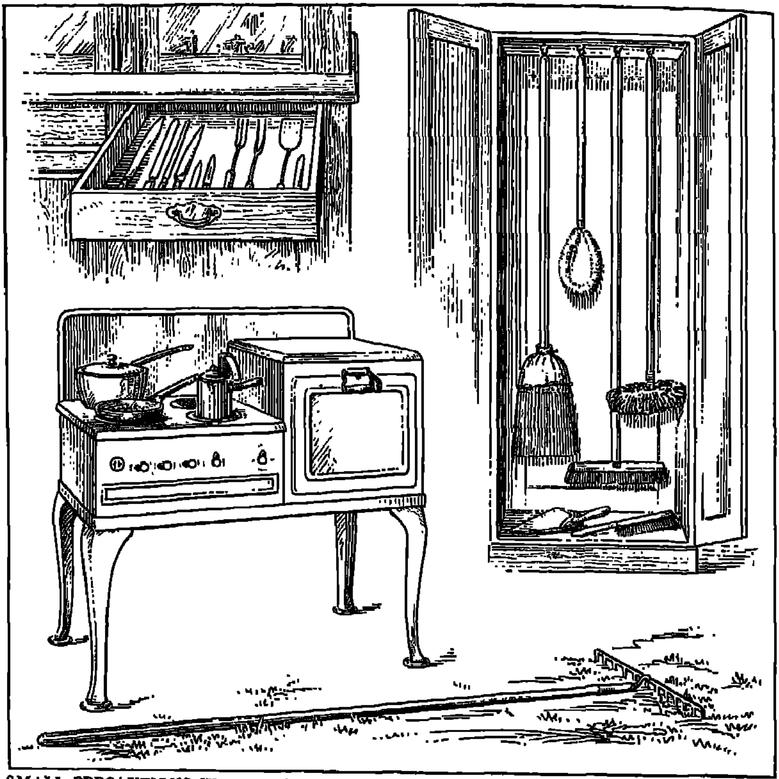
COMPARE THE NUMBER OF TEETH OF AN EGG BEATER'S GEAR WHEELS.

### 8. How can we avoid injuries from machines?

As every one knows, large numbers of accidental injuries are caused by our careless use of tools and machines. The number of such injuries could be very much reduced if we used reasonable care in working with tools and machines.

There are simple things that we can do to make the use of tools safer. Many of our common tools have points, or sharp edges, or are heavy. Many accidents are due to leaving tools where they do not belong. Friends, or members of the household, stumble over the misplaced tool, come in contact with a sharp point, or have a heavy object fall on them. A rule which will prevent many of these accidents is to have a place for each tool and machine and to put each thing back in its place each time it is used.

Never leave tools or household machines on a stair. Have a place for brooms or other long-handled tools where they cannot fall across a passageway. Be sure that the place for heavy tools is secure so that they cannot fall on someone passing by. Always put knives and other pointed tools away with the points down, or pointing away from the person who will next pick them up. Knives put into a drawer compartment must always have the handles out. In using a knife cut away from you, not towards you, whenever possible. Never run with a pointed tool, such as a pair of scissors, or



SMALL PRECAUTIONS WITH TOOLS MAKE HOMES SAFER. WHAT HAS BEEN DONE FOR PROTECTION IN EACH OF THE ILLUSTRATIONS?

an open knife. Do not leave doors to storage spaces, or drawers, open for the passer-by to run into. Turn the handles of long-handled cooking utensils, such as a frying pan, so that any person passing the stove does not run into a handle and so knock off a hot pan.

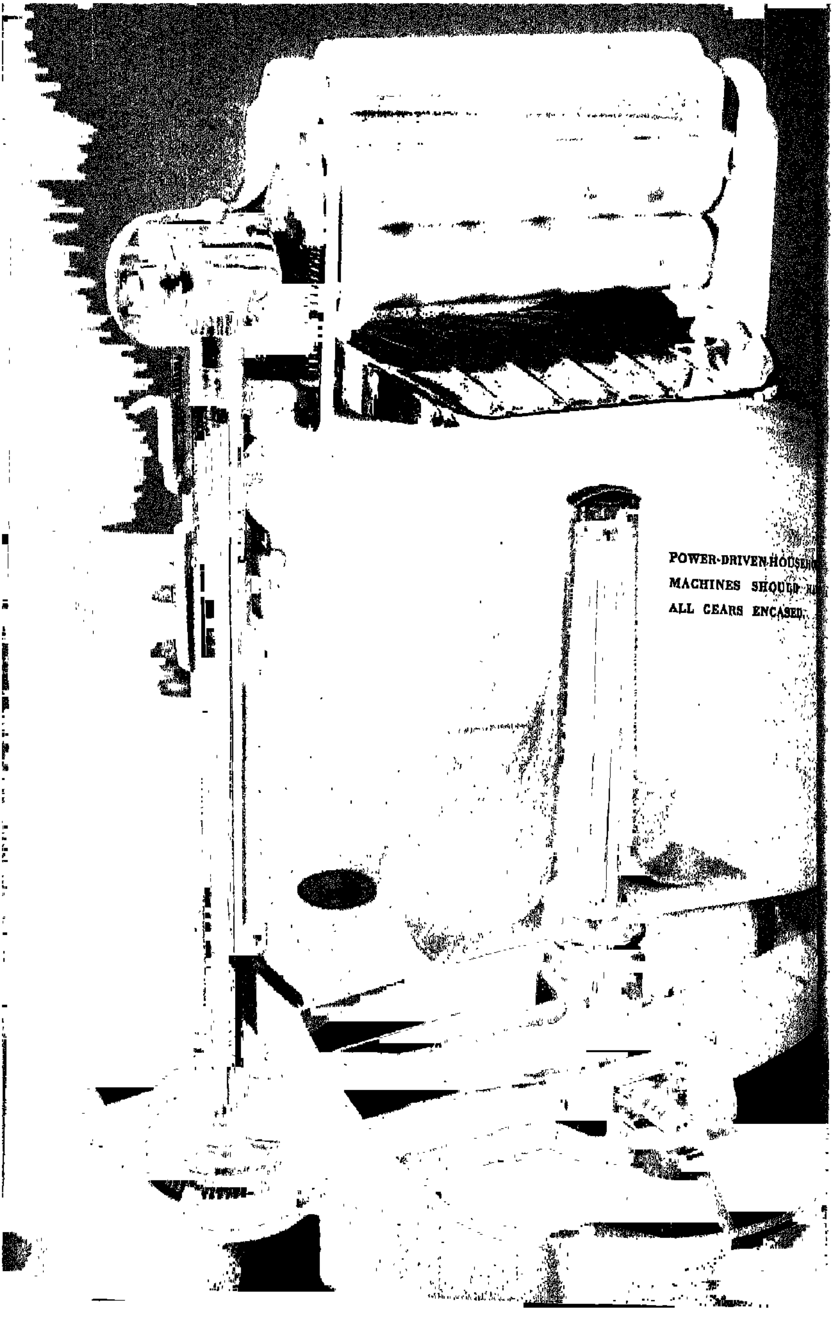
Machines with turning wheels, belts, and gears present some extra hazards. This is especially true of power-driven machines that cannot be stopped instantly. Fingers are often caught in moving wheels, under belts, or in the teeth of gears. Projecting bits of clothing are often caught in the moving parts of machines. Girls dressed in loose, flowing garments with hanging sleeves, loose ties, or belts, should not try to operate household machines.

As far as possible the moving parts of machines should be guarded by being covered with shields. All gears should be covered or cased and moving belts should be protected by guards. Do not buy machines without such protecting covers.

A few household machines are the cause of many injuries. These are electric fans, sewing machines, washing machines, and power-driven ironing machines. Vacuum cleaners and mechanical refrigerators cause fewer accidents due to moving parts because their parts are usually encased.

Every electric fan should have a guard about its blades. Do not buy a fan without such a guard. Fans for use inside automobiles where there is little space have flexible rubber blades that do little damage. Always stop a fan to make any adjustments. Do not try to fix or change the pitch of a fan while it is in use.

Clothes wringers cause many injuries. This is especially true of the wringers on power washers. The wringers on these washers should have the gears cased. The gears or belt used to drive the washer should be cased. The wringer should be equipped with a device for instant release of the pressure so that in case of accident the pressure can be released at once. Examine the provision for such release before buying a new washer or wringer. The control of the power, such as the electric switch, should be placed where it can be instantly shut off in case of accident. Always shut off the power and release the pressure before trying to make any adjustment with a wringer. If clothes jam in a wringer, do not try to straighten them out with the machine going. Stop the machine first. Fingers are more important than torn clothes. Do not try to push things into the wringer with the fingers. Keep your body



POWER-DRIVEN HOUSEHO
MACHINES SHOULD HA
ALL GEARS ENCASED.

away from the wringer. Do not wear hanging garments that may catch in the machinery while using a washing machine.

The same safety rules apply to power ironing machines that apply to the use of power wringers. Gears and pulleys should be cased. The pressure release should be most easily available and work instantly. Keep fingers away from the point where the roll turns against the shoe. Remember that the shoe is hot and that burns, in addition to mashed fingers, may result from getting caught. Do not try to straighten garments in the ironer without first releasing the pressure. Do not work about an ironer with loose hanging garments.

The belts on sewing machines should be guarded. Keep the fingers back from the moving needle. Do not try to adjust work that is caught without first stopping the machine and releasing the pressure on the "pressure foot." Adjust attachments only when the machine is not running.

Recently power machinery for home woodworking and metal shops has become very popular with men and boys. These are, for the most part, lathes, saws, drills, and polishers driven by electric motors. Some of the cheaper ones are not provided with adequate guards. Pulleys from the motor to the machine should have guards. Moving saws should have guards so that fingers cannot be pushed into the saw along with the work. Band saws should be covered. Buzz saws should be guarded on top and at the back. Always stop any of these machines before making an adjustment. Buy good machines, even if you can have fewer parts because these cost more. See that guards are built into the machine.

*Examine all of the power-driven machines in your home. How is each driven? List the possible sources of danger in each. Look for uncovered gears, belts without shields, moving rollers, and so on. Make a set of recommendations for improving the safety of these machines.*

MUCH WORK IS STILL CARRIED ON WITH HAND TOOLS.

## 9. What sources of power can be used to drive machines?

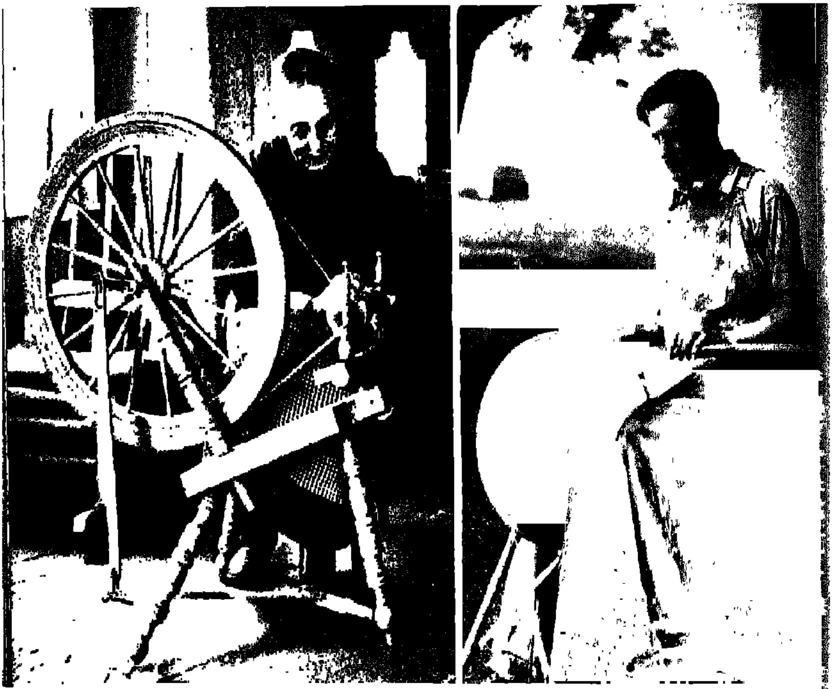
As we have seen, our simpler machines are devised to help us to multiply our own limited powers, or to help us to do work quickly which we could only do in much longer time without the aid of machines. In other words, many of our machines are operated by man power. In spite of the very rapid development of other sources of power, there are yet many places in the world where man power is almost the only power used to run machines. In our own country in recent years many men have been unable to earn a living. In attempting to give these men an opportunity to work for a living, governmental agencies have often specified in contracts for public works that as much as possible of the work be done by human labor, thus giving work to more people.

You can get some picture of the extent to which human power is still used if you will try to recall the tools and machines which you have seen operated by hand. How much work is yet accomplished with the pick, shovel, ax, and wheelbarrow? Despite modern snow-removal machines, New York City may employ 50,000 men to clear its streets after a heavy snowfall.

How many kinds of machines are yet operated by means of a hand crank? How many household or kitchen appliances have you at home that are operated with a crank? A variation of the crank is the machine operated by means of a foot treadle. Usually the operator must stand up to run a machine with a crank. With a treadle the operator can either stand or sit.

*See if you can find a wheel eighteen inches or two feet across. Mount this on an axle so that the wheel turns with the axle. On one end of the axle where it projects beyond the wheel mounting, fasten a crank. This crank should be about six inches long. (It will work better if it is curved.) On the end of the crank fasten a straight bar or stick with a bolt so that it can turn freely. To the end of this bar fasten a treadle so that it is tilted up from the floor. This can be fastened by boring a hole in the bar and in the treadle and tying the two together with heavy cord. Try operating the wheel with the treadle. Can you get a belt on the wheel and run some other machine with it?*

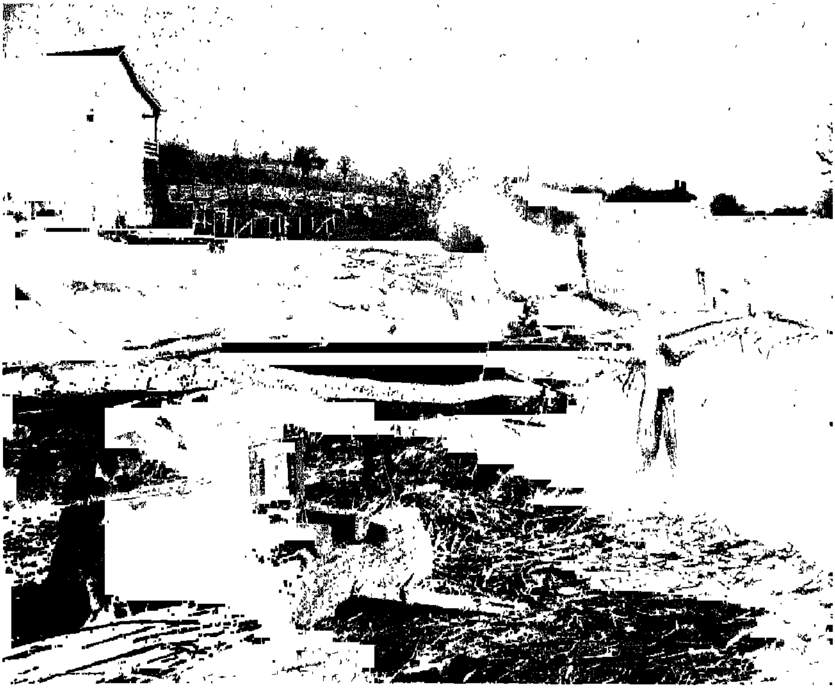
At one time practically all such machines as the following were treadle operated: the sewing machine, the spinning wheel, the grindstone, the lathe, the band saw, and the dentist's drill. Looms for weaving were also partly operated by a treadle and partly by using the hands and arms. Do you



THESE TWO FOOT-TREADLE MACHINES WERE ONCE FAMILIAR IN MANY AMERICAN HOMES.

have any treadle-operated machines in your home or neighborhood? What type of machinery has displaced these?

As you know, domestic animals are used instead of men to supply power. Different animals are used in different parts of the world. Animal power usually can be made much more effective if used to move machines with wheels. The most familiar use of animals for power is that of pulling or carrying loads. There are machines, however, that are operated by animal power. One of these machines is the sweep. In this machine a long pole or lever extends out from the top of the axle of the machine to be driven. The horse, ox, mule, or donkey is hitched to this lever and goes round and round in a circle about the machine. Often a smaller pole is extended in front of the animal to which a lead rope is tied, so that, once



SOME SORGHUM MILLS ARE STILL OPERATED BY HORSEPOWER. CAN YOU EXPLAIN HOW THIS MACHINE WORKS?

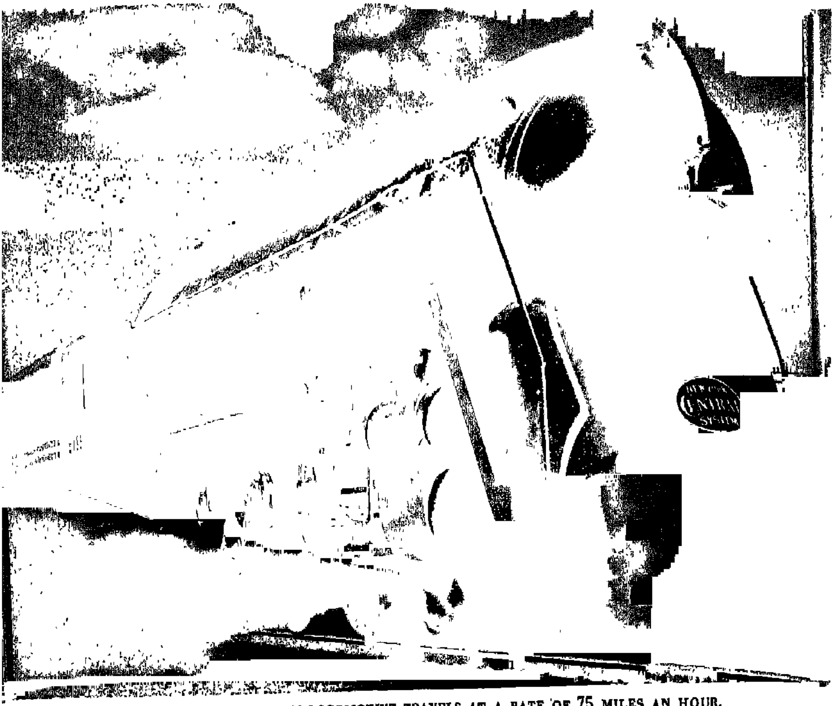
started, the animal leads itself around the circle. The driver often sits upon the sweep and rides round behind the animal. On farms such sweeps are still used to drive corn shellers, and small mills for grinding grain. In some parts of the country, sweep mills are used as sorghum mills for crushing the sorghum stalks to get juice for molasses.

Another old type of animal-driven machine is the treadmill. The treadmill consists of an endless track which serves as a belt passing around two rollers. The gears to drive the machinery are attached to one of the rollers. The animal walks over the floor of the mill. Usually this is pitched uphill. As the animal walks up, the floor rolls out behind. The rollers turn as long as the animal continues to walk. This moving floor serves as a belt upon the roller which drives the machinery. Usually there is a pen about the floor with a gate in the lower end. The pen keeps the animal from jumping off. Large treadmills are operated by horses, donkeys, or oxen. Small ones are often operated by dogs. The treadmills can be used for operating grinding machinery or for pumping water. Small dog-operated treadmills were once used for running churns and other household machines.

A great advance was made when some man had the imagination to try to use the natural forces of wind and water to drive his machines. Probably ships were the first to be driven by sails. Then sails were placed about a wheel or axle and made to drive machinery. A large wheel is used to drive smaller gear wheels. This increases the speed of the driven machinery in a sluggish wind. In Europe windmills are often used for driving milling and woodworking machinery. In our country windmills have been used principally for pumping water, although of late small mills have been used to drive electric generators.

Flowing or falling water can be used to turn a wheel over or under which the water flows. The level of the water can be raised by means of a dam, thus increasing the pressure. A dam also serves to create a reservoir for the storage of water in dry times. The water can be released as it is needed for power. Water-power wheels are usually large and the gears which they turn small to give greater speed to the machinery turned by the slowly moving wheel. Many water-power plants have been used for turning milling machinery. Such power has been used for turning, spinning, and weaving machinery, or for driving woodworking tools. There are still many water-power mills in our country. Now most water-power plants are used to drive electric generators and the electric power carried to where it is needed by transmission lines. The electric power is used for an almost endless number of machines.

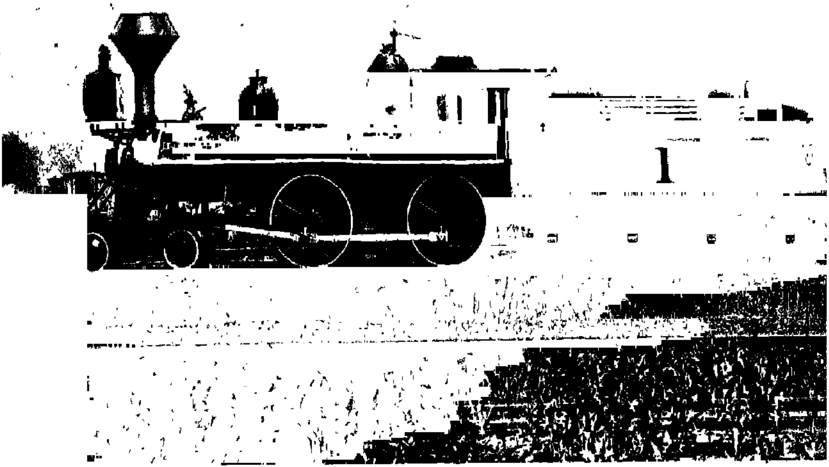
MANY OLD MILLS ARE OPERATED BY POWER FROM RUNNING WATER.



THIS MODERN LOCOMOTIVE TRAVELS AT A RATE OF 75 MILES AN HOUR.

The greatest increase in the use of power-driven machinery came when a way was found to turn the heat energy from burning fuel into mechanical energy. The first engine for doing this on a large scale was the steam engine. In the steam engine the heat from burning fuel, such as wood, coal, or oil, changes water in a boiler into steam, and the steam into useful mechanical energy. (See pages 323-324.)

The first practical steam engine was used for pumping water out of mine pits. Soon steam power was used in England for driving, spinning, and weaving machinery in plants manufacturing cloth. Steam engines were soon used to drive ships and afterwards to drive locomotives that could pull long trains of cars on tracks. Before the use of steam practically all ships had been driven by oars pulled by men, or by wind. Most loads were pulled by oxen or horses. The use of steam



COMPARE AN EARLY STEAM LOCOMOTIVE WITH THE ONE TO THE LEFT.

made it possible to carry on manufacturing processes at places removed from the rivers where there was abundant fuel. With the coming of the steam locomotive it became possible to move fuel in large quantities to the places where it might be needed. Manufacturing then could be carried on in almost any place near the source of the raw materials used.

Up to the time of the wide use of steam engines much manufacturing was done by craftsmen at home or in very small plants with a very few workmen using hand tools or tools driven by man power. For example, shoes were sewed and pegged by hand. Women spun the flax fiber and wool used for clothing by small hand wheels in their homes. Cloth was woven on hand looms, often in homes, sometimes in small weaving establishments. Stockings were knit by hand. Travelers went horseback or by stagecoach.

### 10. Which costs more, man power or machine power?

Anyone living in our present world knows that it is possible to build power-driven machinery that can do the work of many men. From the point of view of the man owning the machine it would seem to cost less to buy and operate such a machine than to depend upon employing many men to do the same work.

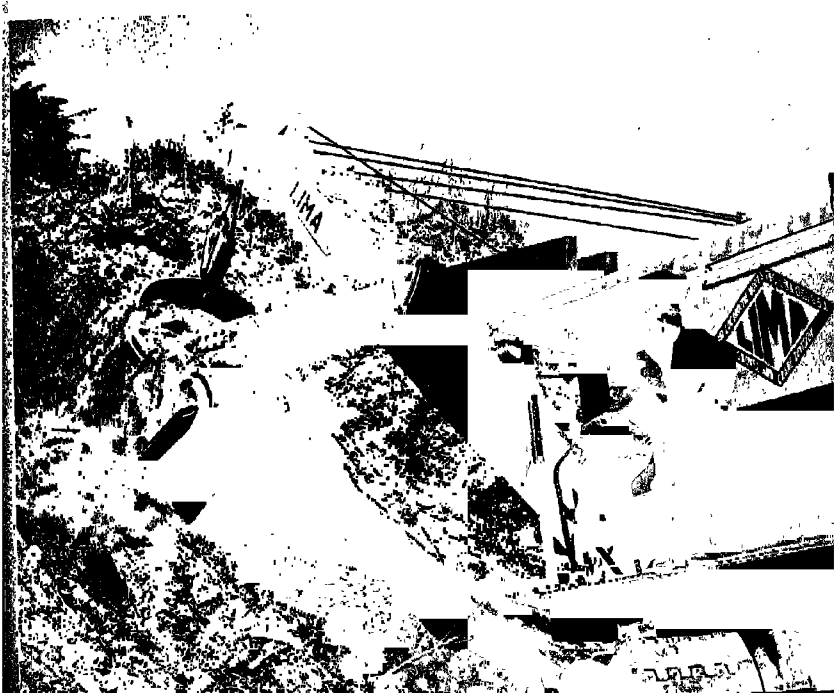
We also know that there are many people who are unable to earn a living, because machines have been invented to do much of the work which they have been trained to do. For these people it would seem that the machine which has been used to take away their employment is indeed a costly one. The working people who are displaced by power machines must live and must have the opportunity to earn a living. This opportunity must be provided by our society. In many

CAN WE SOLVE OUR PRESENT-DAY PROBLEM OF WORK?

cases the furnishing of a living for unemployed people becomes an enormous expense for those that are employed. When this is true, there is no question but that the money saved in wages by the use of power machinery has to be paid back in taking care of the people thrown out of employment because of machines.

We can see these problems more clearly if we can understand the distinction that the scientist makes between work and labor. You will remember our earlier definition of work, that work is done when some force moves through a distance. The energy for doing such work might come from a boy, a horse, a waterfall, or a steam engine. If there is no movement there is no work. A famous illustration of this notion is of a team of horses holding a load on a hillside. In the scientist's definition the horses are doing no work, but they may be laboring considerably. Properly, we speak of a man digging

A POWER-DRIVEN MACHINE CAN DO THE WORK OF MANY MEN.



a ditch, or carrying a bag of wheat, as working. These men are also performing labor when doing such strenuous tasks.

A man who sits before a machine and pulls a lever to make the machine go does very little work. The machine does the work. The man may be tired by the end of the day from sitting in one positon and continually repeating the same motion. We think of his employment as labor. He receives wages for what he does, but most of the work is done by a power-driven machine.

A man digs a ditch with a pick and shovel. At the end of the day he has dug the ditch for a distance of fifty feet. He has labored tremendously. His work may be worth two dollars to an employer. Give this man a tractor and ditching machine and he can dig half a mile of the same kind of ditch in one day. He has produced a much greater quantity of work and with less labor than he would if he had dug fifty feet with hand tools.

At one time we paid people for the amount of labor. One man working with hand tools could do nearly the same amount of work that another could. Now we tend to think of paying for the amount of work actually produced or the output. If we can get a much greater amount of work done in less time and with less labor it seems much cheaper.

In the beginning, we built many machines to save ourselves labor, to make the doing of work easier, for human beings. We talk of labor-saving machines. Now we begin to see that if we reduce labor too much, we must find some sane means for those thrown out of employment to make a living.

Our machines make it possible to make things which we could not have at all without power and modern tools. We can also have these things in much greater quantities. How many automobiles a day does one of the big assembly plants turn out? How many automobiles a year could Henry Ford build in his original bicycle shop? Do you think recent inventions have helped in building such a large organization?

We have many things (often at a small price) that our grandparents, no matter how wealthy, could not have at all. Go into any ten-cent store and look about at the things now easily available. *Ask your grandmother what a good paring-knife cost when she began housekeeping.*

We can also produce many kinds of goods in enormous quantities. Farmers can produce great quantities of foodstuffs. Bakers can make an enormous amount of bread which comes to the home ready sliced. Mills turn out millions of yards of cloth. In spite of all this some people go hungry and are poorly clothed. The farmer's produce sometimes rots on the ground because it cannot be delivered to the people who need food at a price that will pay the farmer for producing it. We have built machines that give us almost endless power to produce things which we need, as well as many things which we can get along without. Our modern problem is to distribute these things to people and to find some way to make it possible for great numbers of people to earn the money to buy them.

Machines make it possible to produce great quantities of goods at low cost. But we have not yet learned to adjust our machine production to allow everyone to afford the benefits of large-scale manufacture of goods. There are many people who say that we might be happier if we made fewer things, lived more simply, and distributed the opportunity for having these few things more widely.

### THINGS TO DO

1. Make a collection of pictures of tools used by very early people. Post the collection with appropriate labels and explanations on the classroom bulletin board. Of what

materials were these tools made? What advantage did each give the user over working with his bare hands? Start a school collection of tools used by early people.

2. If you can find in your community a plow, shovel, or scythe used between the Revolutionary War and the Civil War, see if you can arrange an exhibit for the class. Compare the amount of work that can be done with these tools and that which can be done with tools made for the same purposes today.
3. Is there a spinning wheel in your neighborhood or in your city museum? How does it work? How long would it take to spin wool enough to make a suit of clothes? Linen enough to make a tablecloth?
4. How are the soles and heels of your shoes made to use friction in helping you walk? Explain.
5. Ask some boy in the class to bring a worn-out alarm clock to class. Take the clock out of the case. How many gear wheels does the clock have? What is the gear ratio between the wheel attached to the spring and the next wheel? Is the speed of the next wheel increased or decreased by this gearing? Explain.
6. How many hand-power machines do you have in your home? How is each operated? In your opinion would there be any real economy in converting these into power machines? Take into account the first cost of the power machines and the number of times the present hand machine is used in a day or week.
7. List the people that you know who are out of work because of some change in machinery. List the people that you know who have taken new positions in the last year because of some new development in machinery.
8. Visit the nearest industrial museum. Some of the larger ones are the New York Museum of Commerce and Industry, the Franklin Institute in Philadelphia, the

Smithsonian Institution in Washington, D. C., and the Museum of Science and Industry in Radio City, New York. Look for such exhibits at the next State or World's Fair you attend. Report upon the changes that have taken place in some machine which interests you.

9. What manufacturing process, which was at one time carried on in your home, is now done outside? Why has the change taken place? Does the manufactured article cost less than the one made at home? Consider such things as foods cooked or canned at home, or garments made by the mother in the home.

### SOME THINGS TO REMEMBER

1. Our present ways of living depend upon tools used in doing our work.
2. Machines make it possible to increase enormously our ability to do work.
3. Work is done when any force is moved through a distance.
4. The amount of work done is measured in foot-pounds.
5. A foot-pound of work is done when a force of one pound moves through a distance of one foot.
6. The advantage of a lever depends upon the ratio of the length of the force arm to the length of the weight arm.
7. The point about which a lever turns is called the *fulcrum.*
8. Energy is the capacity to do work.
9. A machine is any device or apparatus used for controlling energy in doing work.
10. The simple machines are the lever, the inclined plane, the wheel and axle, the pulley, and the screw.
11. The resistance to movement set up when the surfaces of two objects rub together is called friction.
12. Friction in machines is reduced by special bearing surfaces, by roller and ball bearings, and by oil.
13. Friction is useful in the operation of some machines.

Wheels against a road, the belt on a driving wheel, and a friction clutch require friction to work successfully.

14. If two wheels are geared together, the speed of the two wheels is in the ratio of the radii of the two wheels. This ratio can be found by counting the number of gear teeth in the two wheels.
15. Moving parts of a machine should be covered with guards to prevent accidents.
16. Power for driving machinery may be obtained from man power, animal power, wind, moving water, steam, electricity, or exploding gas.
17. Power-driven machinery has made it possible to produce great quantities of goods at relatively low cost.
18. Changes in the use of machinery often change the opportunities of many people to earn a living.

## BOOKS TO READ

Adams, J. H. *Harper's Machinery Book for Boys.* Harper & Brothers.

Fisher, Anthony R. *This Man-Made World.* Follett Publishing Company.

Floherty, John J. *Youth at the Wheel.* J. B. Lippincott Company.

Gibson, C. R. *Machines and How They Work.* J. B. Lippincott Company.

Lent, Henry B. *Wide Road Ahead!* The Macmillan Company.

Meister, Morris. *Energy and Power.* Charles Scribner's Sons.

Van Loon, Hendrik. *The Story of Mankind.* Garden City Pub. Co., Inc.

Wilson, Sherman R. *Descriptive Physics.* Henry Holt & Company.

Wood, Eric. *The Boy's Workshop.* Cassell & Co., Ltd.

# UNIT NINE

# UNIT NINE

# How Science Makes Us All Magicians

## WHAT THIS UNIT IS ABOUT

On a bright summer day in our part of the world we keep warm without any difficulty. Sometimes we seek protection from the sun's rays. But in the wintertime we are often uncomfortable even when the sun shines. We put on warm jackets or overcoats. How can a jacket or overcoat keep us warm?

Indoors, heat comes through furnace registers or radiators. How does heat get into and out of a furnace? There is a fire in the furnace. But why does a fire make heat?

If we ride on a train, we say that heat makes the locomotive go. The engine carries a load of coal, or a tank of oil. There is a fire in the firebox under the locomotive boiler. How can we build a fire under a tank of water and make it pull a heavy length of railway cars?

If you came to school in the family automobile, heat in the motor under the hood furnished the power to bring you to school. There is a fire in each one of the cylinders of the engine as the motor turns. But you cannot see any fire, and no one seemed to light a fire in the engine. What makes a gasoline engine go?

A match lighted in the dark makes light as well as heat. An electric lamp makes a brilliant light, but it also makes some heat. A piece of iron heated in the fire glows in the dark. The sun furnishes us with both heat and light. How can we get both heat and light from the same source? If we close our eyes we do not see. How are eyes built to see?

Today in many places light for night work comes from electricity. If you want to make toast at the breakfast table, you simply push a plug into an electric outlet and the wires in a toaster glow with enough heat to toast the bread quickly. How can an electric current turn into heat and light?

Many of our common household machines are operated by electric motors. These include fans, vacuum sweepers, refrigerators, furnace blowers, food mixers, floor polishers, and many other machines. Can you explain how an electric motor turns? The motor contains electro-magnets. Do you know how to construct an electro-magnet? What other machines with which you are familiar use electro-magnets in their operation?

These are some of the questions that we shall try to answer in this unit. Do you have some others? You might look at the problems on the page following this. Then take a sheet of paper and make a list of your own questions that you would like to ask in working with this unit.

# How Science Makes Us All Magicians

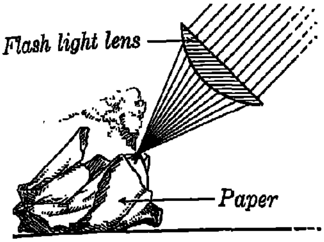
## UNIT PROBLEMS

1. What makes things burn?
2. How can we keep warm?
3. How can we prevent fires?
4. How are fires extinguished?
5. How are fires managed in fireplaces, stoves, and furnaces?
6. How can we measure temperature at home?
7. How is heat carried from place to place?
8. How can heat make an engine go?
9. Why do hot things often make light?
10. How do lamps make light?
11. What makes the reflection in a mirror?
12. How do we see?
13. How does a camera take pictures?
14. How can we have heat and light from electricity?
15. How does a switch control electric current?
16. How can an electric current make a magnet?
17. What are some machines that use electromagnets?

## Heat and Energy From Burning Fuels

### 1. What makes things burn?

If you step into the sun on a warm summer day you can feel the heat from the sun. If you go about with face, arms, or back exposed to the sun you will get the skin



A FIRE CAN BE STARTED WITH A LENS AND HEAT FROM THE SUN'S RAYS.

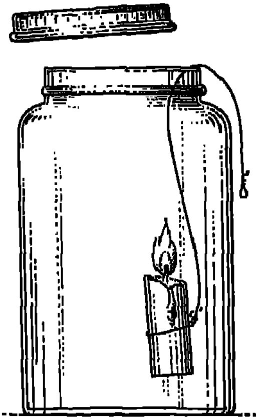
scorched. Severe burns sometimes result. If you lay a piece of paper in the sun for awhile, it becomes warm but does not burn. *Hold a lens like that from a flashlight in the sun over the paper. You can draw enough of the sun's rays together in one spot to burn a hole in it. Perhaps you can get the paper to blaze. If you turn the rays through the lens to a concrete floor, a stone, or a piece of iron, these things get warm but do not burn.*

If you pound on a piece of metal with a hammer, the metal gets warm but does not burn. If you file a piece of iron, the iron gets hot, but does not burn. A rapidly turning drill boring through a piece of metal gets hot, but does not burn. With a piece of steel you can strike sparks from a flint. Neither the steel nor the flint appears to burn. If the sparks can be made to fall on very light dry pieces of wood, you may be able to get a fire.

*Rub your finger quickly along a somewhat rough surface. You can feel the heat developed by the friction.* There is no fire. You can burn your hands this way. Rub a match along a surface and the match bursts into flame. Apply the flame of the match to a wood splinter and it will burn. Apply the match flame to the end of a bit of wire. The wire gets hot but does not burn.

FLINT AND STEEL WERE USED IN MAKING FIRE IN COLONIAL TIMES.

*Bend a small loop in the end of an eight-inch length of small-sized wire. Fit a little birthday candle into the loop. Find a glass jar with a lid. Either a fruit jar or a pickle jar will do. Lower the candle into the jar so that it stands free of the sides. Bend the upper end of the wire over the edge of the jar. Raise the candle, light it and lower it again. The candle will burn brightly in the bottom of the jar. Slip the lid of the jar over its mouth. How long does the candle burn after the lid is put on?*



WHY DOES THE CANDLE GO OUT WHEN THE LID IS PLACED OVER THE JAR?

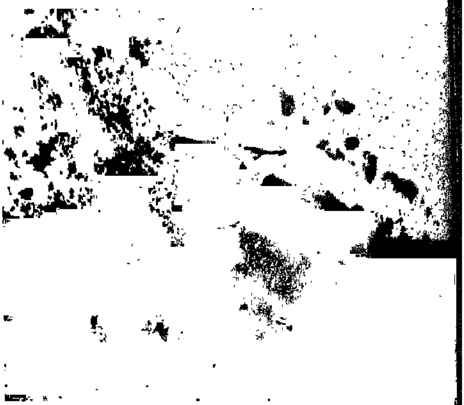
Three things are necessary for burning. First, there must be some substance or material that will burn. Paper, wood, fats, oils, gasoline, and gunpowder will burn. Sand, water, asbestos, and clay do not burn. Iron and steel do not burn under ordinary conditions. *(See page 248 for an experiment for burning iron wire.)*

Second, the temperature of the substance must be raised to a *kindling temperature.* The kindling temperature is the temperature at which a particular substance will burn. This is different for different materials. Pine wood has a rather low kindling temperature. That for oak is higher, and for most coal higher still. Paper has a low kindling temperature. The kindling temperature for iron is very high. The head of a match, made of phosphorus and some other chemicals, has a very low kindling temperature. The pine stick of the match has a higher kindling temperature than the head, but lower than most of the substances which we light with the match.

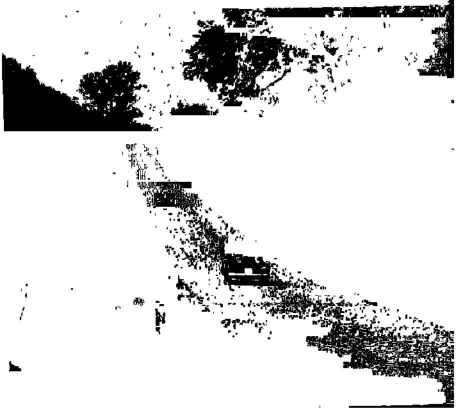
Third, there must be a supply of oxygen for burning to take place. This oxygen supply for all ordinary burning comes from the air. Actually what happens in burning is a very rapid combination of oxygen with other substances to form new chemical compounds.

*Run back through the paragraphs of the last two pages and tell in each case of burning described, what the burnable substance was, how the kindling temperature was obtained, and how the air got to the burning substance? In each case where burning did not take place, or was stopped, which one of these three things was not present?*

BURNING IS CALLED COMBUSTION.



COMBUSTION IS TAKING PLACE IN ALL OF THESE. CAN YOU EXPLAIN HOW?



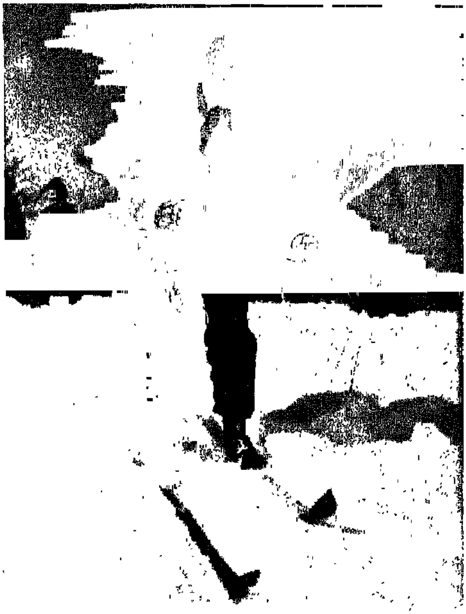
POOR CONDUCTORS OF HEAT HOLD THE HEAT INSIDE THE HOUSE IN THE WINTER, AND KEEP IT OUTSIDE IN THE SUMMER.

Sometimes other names are given to the process of burning. One such name is *combustion.* We sometimes call a substance that will burn a combustible substance. Another term for burning is *rapid oxidation,* the combination of a substance with the element oxygen. Often we think of two kinds of oxidation, rapid oxidation and slow oxidation. Ordinary burning of a fuel is rapid oxidation. The burning of foods in our bodies is slow oxidation. The rusting of metals is also a process of slow oxidation. A very rapid oxidation such as the burning of powder in a gun, or of gasoline vapor in a motor, we call an explosion.

### 2. How can we keep warm?

The oxidation or slow burning of fuel foods, such as sugars, starches, and fats, in our bodies keeps us warm.

Exercise hastens the process. You know that you sometimes get very hot from running in warm weather.



WOOLEN CLOTHES HELP TO KEEP THE BODY HEAT IN.

In cold weather the cold outside air carries heat away from our bodies so rapidly that we get cold in spite of the burning of fuels in our inner heating systems. If our temperatures are lowered too much, we chill and die. Sometimes people actually freeze in cold climates.

There are several things that we can do to keep warm when the weather is cold. We can eat more foods containing the fuels for the body. We can exercise. You have read of people in the cold who had to keep moving in order to keep warm. We can wear clothing that will help to keep the body heat in. Warm clothing does not actually add to the heat of the body. The clothing simply shuts in the heat produced and shuts out the cold air which would carry this heat away rapidly.

Materials through which heat passes rapidly are good conductors of heat. Other materials are poor conductors. Very poor heat conductors are insulating materials.

Paper is a poor heat conductor; so is the air. Some kinds of cloth are better heat insulators than others. Wool and silk are poorer conductors of heat than linen and cotton. Therefore, silk and woolen garments hold body heat in better than linen and cotton. Silk and woolen garments are warmer. Loosely woven cloth is warmer than tightly woven cloth because more air is held in the spaces of the loosely woven cloth. In a wind the air escapes from loosely woven cloth. In cold windy weather wear a loosely knit sweater under a jacket of heavy tight cloth or of leather. Dark colors absorb heat from the sun more readily than light ones. White cloth reflects heat from the sun. In winter wear loosely woven woolen or silk garments of darker colors. In summer wear cotton or linen garments of light color, or white.

*Make a collection of different kinds of fabrics used to make clothing. Label these to show which are best for keeping warm and which for keeping cool. Show on the label why each kind of cloth is good for its purpose.*

We might keep warm with plenty of food and the proper clothing in severely cold weather. We can be much more comfortable if we have a fire to warm the air about us.

If you go camping you can keep warm by finding a place

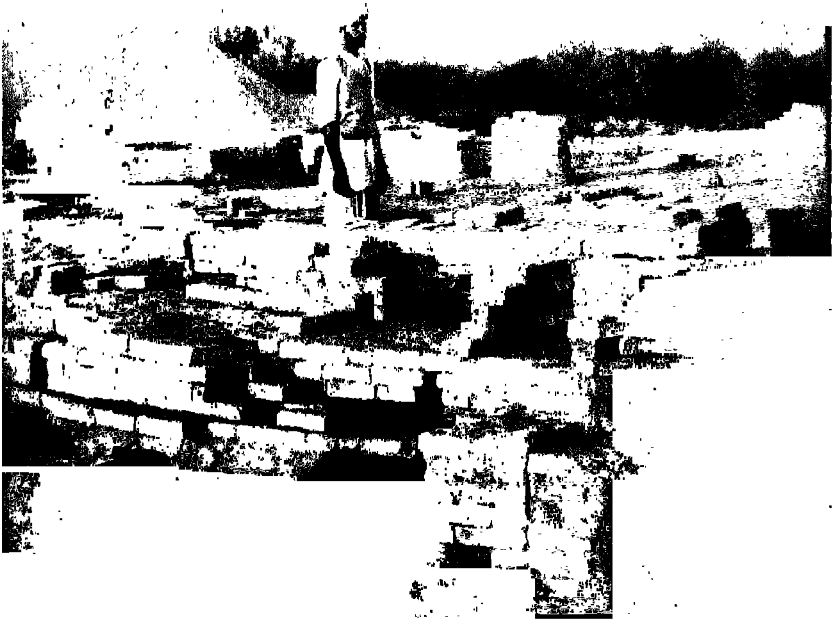
THIS EARLY HOME, YEAR 1, A. D., HAD A CENTRAL HEARTH FOR HEATING.

sheltered from cold winds by a bank and building a fire to heat the near-by surrounding air and camping in its warmth.

It is easier to keep warm and takes less fuel if a fire is made inside a house where less of the warmed air escapes at once. The first fires for warming houses were simply made on the dirt floor in the middle of the one room. A hole in the roof let the smoke escape.

Later fireplaces with chimneys were built. The fireplace was not a very economical way to heat a house. Too much of the heat went up the chimney. Stoves were an improvement, because the rate of burning of the fuel could be better controlled. Most stoves heat comfortably only the room in which the stove is kept. Heating a whole house means having a fire in several stoves in various rooms. The stove requires that the fuel be carried into the rooms where we live and ashes be taken out through the living quarters.

CENTRAL HEATING PLANTS WERE KNOWN IN INDIA 5000 YEARS AGO.



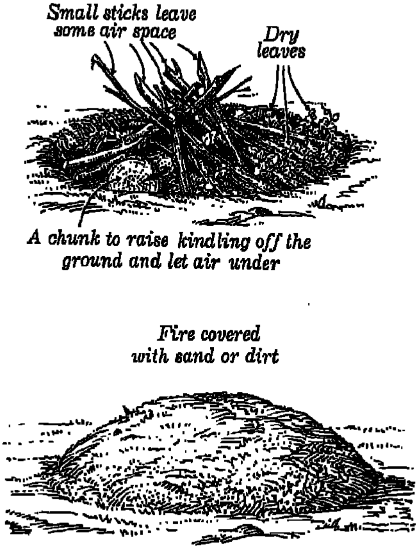
Many modern homes have central-heating plants. The fire is in a furnace, or modified stove, in a furnace room. Often the furnace room is in a basement. Warm air circulates through the rooms throughout the house. In some heating systems the fire heats water in a boiler and the hot water or steam is piped to the parts of the house to be warmed. We can live comfortably in winter in such heated houses without bundling up in heavy clothing.

### 3. How can we prevent fires?

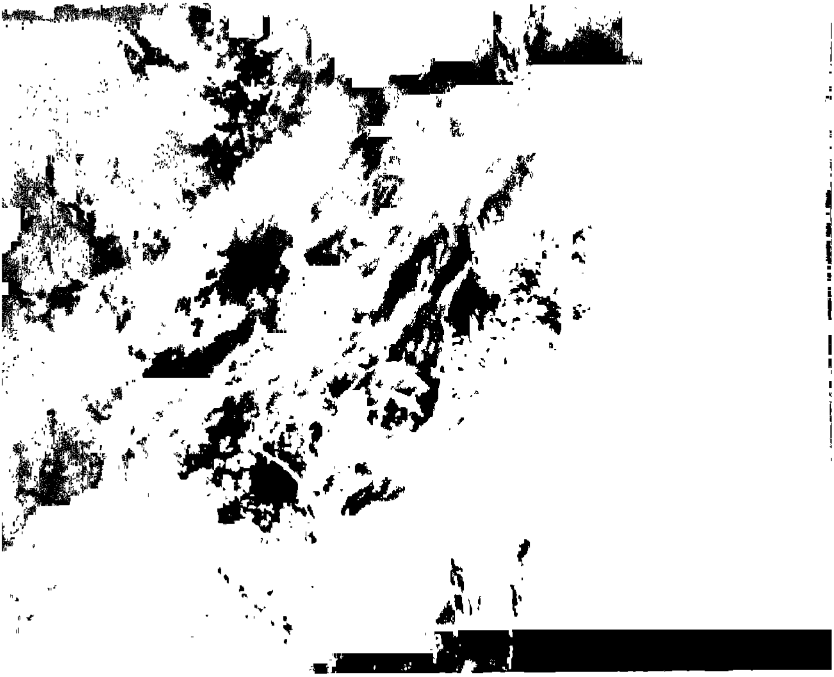
We can scarcely think how we could live without fire. Try to imagine what it would be like eating raw food, living in an unheated home, and doing without all of the manufactured things which burning fuels make possible.

In spite of all this, fire is sometimes a serious menace to our lives. A fire can destroy our most cherished possessions within a few minutes.

If we build a fire out of doors great care must be taken to build it away from materials that will burn easily. This means such things as dry leaves, dead wood, dry grass, and underbrush. In dry weather and on windy days fires spread very rapidly. Always put out a campfire before leav-


Small sticks leave some air space
Dry leaves
A chunk to raise kindling off the ground and let air under
Fire covered with sand or dirt

CARE SHOULD BE TAKEN WHEN BUILDING A CAMPFIRE IN THE OPEN.



CARELESS PICNICKERS SOMETIMES START FIRES LIKE THIS.

ing it. Water can be poured over a fire. If water is not near, earth or sand will put out a fire. Why? Smokers cause many fires by throwing cigarette stubs on materials that burn easily.

When we have a fire in a house, we must always take care to keep it under control. This means the fire in the stove, furnace, cooking stove, fireplace, or lamps, if lamps with open flames are used. Do not store rubbish containing paper or old clothing near the furnace. Keep cloths off the cookstove. Provide a screen for the fireplace. Do not store gasoline, naphtha, or benzine for cleaning garments near any source of heat. It is always better to clean garments out of the house in the open air. Keep matches in metal containers. Do not look into the fuel tank of an automobile with a match. Never start a fire with kerosene or gasoline.

*Gather pictures of fire hazards in your neighborhood for* *the school bulletin board. If some members of the class belong to a candid camera club, perhaps a collection of actual photographs can be taken.*

### 4. How are fires extinguished?

After destructive fires start, they are most often put out by covering the burning material with something which will shut off the air and therefore the oxygen supply. We often speak of smothering a fire.

The commonest material used for putting out fires is water. You have often seen water poured on fires, or have seen a fire department turn streams of water on a burning building. Burning gasoline or oil will float on water and still get air enough to burn. For this reason gasoline or oil fires are often put out with earth or sand. Remember this if you ever have an automobile fire.

Fire extinguishers smother fires by covering them with bubbles or blankets of gases that do not burn. Some fire extinguishers send out a stream of nonburning gas mixed with water. The two most common gases used in fire extinguishers are carbon dioxide and carbon tetrachloride. The carbon-dioxide extinguisher is usually fairly large and works by simply turning it upside down. The carbon-tetrachloride extinguisher is smaller and is operated by means of a handle and plunger at one end.

Public buildings, such as schools, are as a rule required to have fire extinguishers placed at certain points in the halls. Some homes also take this precaution now. A type of fire extinguisher, which is a round glass bulb filled with some nonburning gas, is inconspicuous and, therefore, particularly suitable for homes.

Sometimes a person's clothing catches fire. If this should happen to you, do not run. Running supplies air to the fire more rapidly and increases the fire. Lie down on a rug and roll, or better still roll up in the rug. Any heavy cloth, as a blanket or rug, can be used to smother such a fire. Simply wrap up the person whose clothing is burning with any heavy material that you can reach.

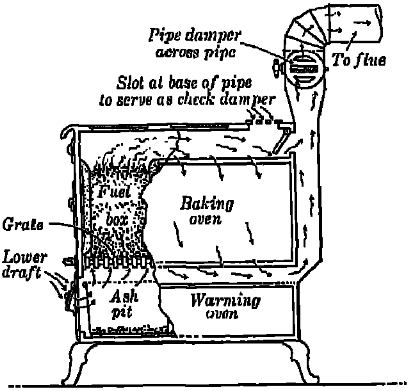
Some fires can be fought by removing the combustible material ahead of the fire. Firemen sometimes cut away a part of a wooden building. In case of a large city fire, firemen may find it necessary to dynamite several houses in order to remove the combustible material ahead. A grass or brush fire can often be controlled by cutting back the grass or brush ahead of the fire. Sometimes a plow is used to throw up earth over the dry burnable material.

### 5. How are fires managed in fireplaces, stoves, and furnaces?

Nearly everyone needs to build a fire or to adjust heating equipment, at one time or another. It is necessary to remember some simple things about combustion that we have listed on page 304. Add to this a little bit of information about the construction of most heating devices and you should be able to keep a fire going.

THESE ARE TWO COMMON KINDS OF FIRE EXTINGUISHERS IN USE TODAY.

Let us begin with making a campfire in the open. Kindling material to start a fire should be light, thin, and dry. Water does not burn. Fuel saturated with water burns very slowly, if at all. Thin pieces can be raised to a kindling tempera-



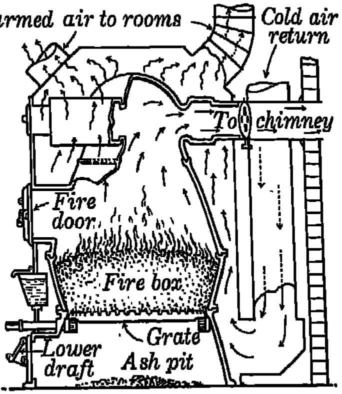
THIS DIAGRAM SHOWS THE ARRANGEMENT OF DRAFTS AND DAMPERS IN A STOVE.

ture with the small flame of a match more readily than large pieces. Pile the kindling loosely so that air can get through it. If paper is used do not use too much, and crumple it loosely. Do not pile on heavy fuel until the kindling is burning briskly and has developed considerable heat. If sticks are piled crosswise, openings between the sticks are left for the air to come through.

Build a fire in a fireplace in the same way. The circulation of air from the fireplace must go up the chimney, if smoke is not to escape into the room. Some fireplaces have a throat damper across the chimney just above the fireplace. This is often closed in cold weather when there is no fire. Be sure that this throat damper is open before lighting the fire. If there are ashes in the fireplace, rake these back so that air can get under and through the kindling and wood.

Stoves and furnaces are all built on very much the same plan. A cookstove that burns wood or coal operates like any other stove. The firebox for a boiler in a hot-water or steam-heating system works like a simple stove.

The first thing to do is to find the openings into the firebox. The air which supplies oxygen for rapid burning comes up through the fire from below. The draft for supplying this air is an opening near the bottom of the stove or furnace. Often this is an opening into the ashpit below the grate. If you cannot find this draft, the same effect can be had by opening the ashpit door a little. In starting a fire the lower draft can be left open. This will burn a quantity of fuel in a short time. If ashes are allowed to choke the grate on which the fuel rests, little air can get to the fire, even with the lower draft open.



MOST FURNACE DRAFTS AND DAMPERS RESEMBLE THOSE OF A STOVE.

Now look for the check dampers. The check dampers are in the pipe or the connection upon which the pipe to the furnace flue is fastened. These are of two kinds. One is simply a door in the smoke pipe. Find this. It should be closed in starting the fire. After the fire is burning well, it can be opened. It slows down the burning. This damper lets in cold air above the fire and tends to check the rapid flow of heated air up the chimney. Another type of check damper is simply a disk on a pivot which sets across the pipe when closed. This checks the flow of air up the chimney. This damper should be turned across the smoke pipe to check the fire.

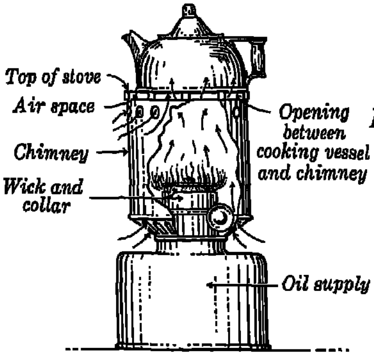
Some stoves and furnaces also have a damper in the firebox door. When this is opened it lets in cold air above the fire and serves to slow down the burning. This is opened when a steady slow fire is desired. It should be closed when starting a fire. In an emergency the same effect can be had by opening the door to the firebox.

Common oil stoves are of two kinds. One kind operates just like an old-fashioned oil lamp. It has a wick which dips into a pot of oil. A chimney provides the proper flow of air. The burning is adjusted by a screw or lever that turns the wick up or down. The wickless stove uses an asbestos wick instead of a cloth wick. As a matter of fact, it works like the other type of stove except that the wick does not burn nor char.

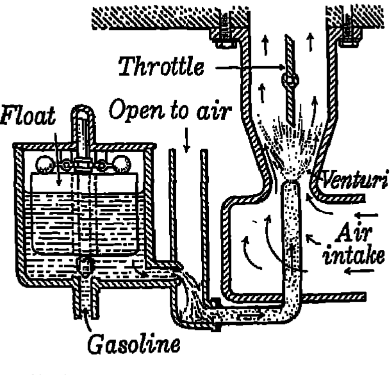
The air supply for an oil stove comes in at the bottom of the chimney. If you examine such a stove, or an oil lamp, you will find an air space around the base of the chimney. This must be clean and open for the stove to work properly. There must also be a space at the top of the chimney between the cooking vessel and the end of the chimney. The stove will not burn properly, or may smoke, if this is partly closed. Stoves have a rack above the chimney which raises the cooking vessel enough to permit the circulation of air and the escape of unburned gases. You can try the effect of closing this space by lighting an oil lamp and putting a pan over the chimney. Do not leave this on for any length of time.

The fuel mixture for an oil stove must be right or the stove will smoke. In starting the stove, if you turn the wick up too high it will give too great an amount of oil and the stove will smoke. Wick stoves must have the wicks trimmed and cleaned.

Gas stoves also work on the chimney principle. *You can*



AIR CIRCULATES THROUGH THE BURNER OF AN OIL STOVE.



AIR MUST BE MIXED WITH THE FUEL IN THE CARBURETOR OF A MOTOR.

*best see this by working with a laboratory Bunsen burner. You can see that this consists of a tube fastened to a broad base. A movable ring opens and closes holes in the base of the chimney. A tube opening into the bottom of the chimney connects with the tube which supplies the gas used as fuel.*

*Close the ring on the base of the burner. The air supply will now come from above the chimney. Turn on the gas and light it. The flame will be long and narrow. A dish held in this yellow flame will be badly smoked with unburned carbon. Shut off the gas. Open the ring at the bottom. Light the gas again. The flame is blue and the heat more intense. A dish held above the flame is not smoked. You can adjust the openings in the ring to get a very hot, almost invisible blue flame. The problem is to get just enough air for the gas used.*

*If you will examine a gas stove you will find that there is a sleeve around the pipe supplying gas to the burner.* This sleeve opens into the burner. This is the mixing tube. Air comes into it from openings at the edge of the stove and is led up into the bottom of the burner. Gas enters the burner from the pipe inside the sleeve at the same place where the chimney enters the burner. The amount of air can be regulated by turning a little damper which is kept in place by a screw. This screw must be loosened to turn the damper. If the flame is yellow and pans are sooted, increase the size of the opening for letting air into the burner. The principle of adjustment is just like that of a Bunsen burner.

Gas- and oil-burning furnaces work on the same general principle as a simple gas burner. So also does the carburetor of an automobile motor. The amount of fuel and the amount of air necessary to furnish oxygen for complete combustion of the fuel must be found. The adjustments on these devices should be made by a trained service man and not by an amateur.

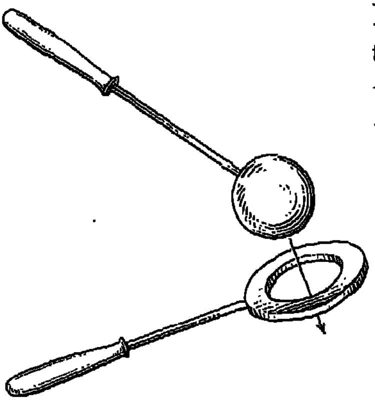
Stoves or furnaces which use large quantities of oil or gas as fuel should be piped to a house flue, so that gases go off into the upper air and not into the house. The gases from burned fuels are often poisonous.

What kind of heating equipment is used to heat your home in the winter? Find out how it works and report to the class.

### 6. How can we measure temperature at home?

We feel hot or cold. Nerve endings in the skin measure temperature for us. Our feeling of hot or cold is not a very accurate measure of temperature. People differ very much in feeling heat. The same person changes from time to time. You have seen difficulties arise in trying to please different members of a family with the house temperature. One person will feet hot when another is comfortably warm, or even chilly.

To measure the intensity of heat or temperature, a thermometer is used. The thermometer depends upon the fact that most substances increase in size when they are heated. These substances also decrease in size when they lose heat, or cool. An iron rod will increase in length when it is heated. It will shorten as it cools. Iron tires are held on the wooden wheels of farm wagons by putting the tires on hot and allowing them to cool. *Try the ring and ball experiment. Try to pass the ball through the ring when both are cold. If the ball will not go through, heat the ring in a Bunsen burner flame. Try putting the ball through the ring when the ring is hot.*

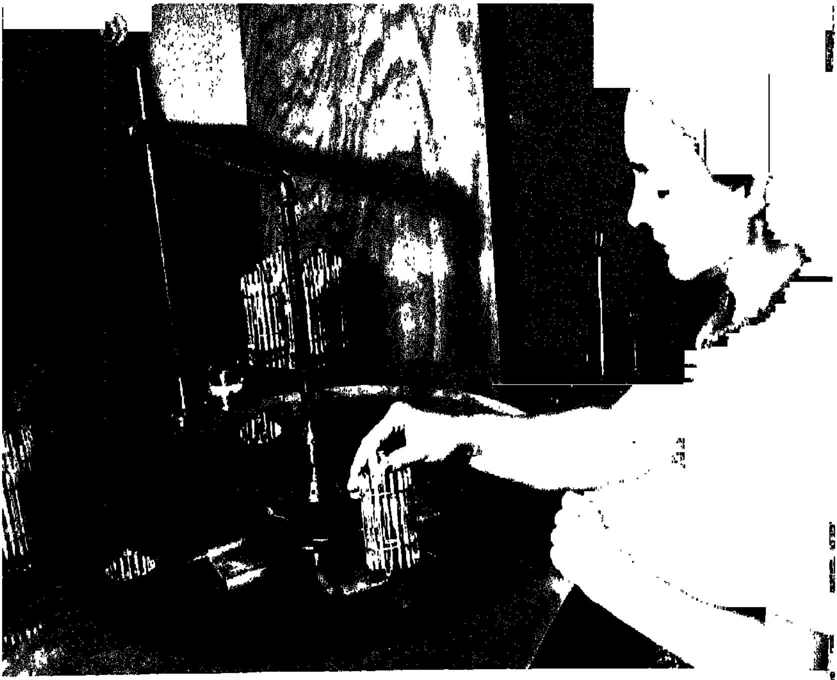


TRY THE RING AND BALL EXPERIMENT.

To make a thermometer it is necessary to find a substance that will expand enough to be seen, but not so much that the scale is unwieldy. A liquid works best for this. In some ordinary thermometers alcohol is used in a fine tube. The bulb on the end of the tube is just a reservoir to hold the liquid. If alcohol is the liquid used, it is colored red or blue. in order to be seen easily. A liquid must be used that will not freeze at low temperatures. For more accurate thermometers, mercury is a better liquid to use. The tube is sealed at the top so that the thermometer is not affected by the pressure of the atmosphere.

The scale on the thermometer is determined by the boiling and freezing points of water at sea level. The height of the mercury column in the tube when held in the steam of boiling water at sea level is marked. The thermometer is then held in a freezing mixture of ice and water. The freezing point is now marked. The space between these two fixed points is divided into equal divisions to make the rest of the scale. Our common thermometers use the Fahrenheit Scale. On this scale the boiling point of water is marked at 212° and the freezing point at 32°. These are written in abbreviated form as 212° .F. and 32° F.

As the mercury in the thermometer tube expands or contracts with changes in temperature, the end of the column moves up and down the tube. The temperature can be read off the scale marked on the tube or on the mounting of the tube. A thermometer hung outdoors will guide you in the selection of clothing to be worn according to the outside temperature. Inside temperatures should be 68° to 70° F. in the winter. A thermometer will help you to know when to regulate the furnace. The normal temperature of a healthy human being is about 98.6° F. The physician uses a thermometer to find out if his patients have fever. High temper-



THE NATIONAL BUREAU OF STANDARDS MAINTAINS A LABORATORY FOR CHECKING THE READINGS OF PHYSICIANS' THERMOMETERS.

atures show that some illness is present and that medical care of some nature is needed by the patient.

*Get an inexpensive thermometer for the home living room. Record the temperature at 7 a. m. and 7 p. m. for two weeks.*

### 7. How is heat carried from place to place?

For heat to be most useful there must be some way in which it can be made to travel from one place to another. If we are to be warmed by the heat in the stove, there must be some way for the heat from the fuel burning in the stove to reach us. If a house is heated from a central heating plant in the cellar, the heat must be carried to all the rooms in the house in order to have a warm home.

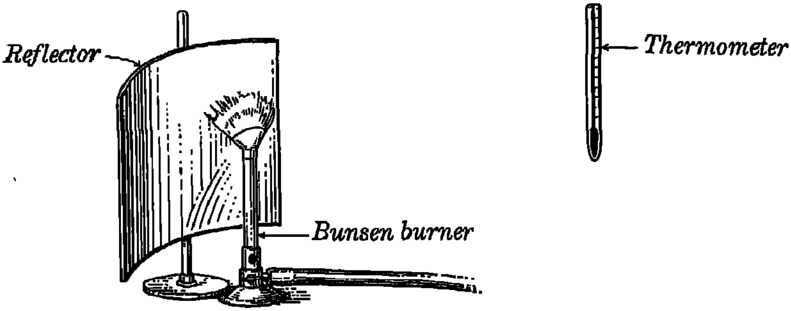
There are three ways by which heat is transmitted. We say heat travels by *conduction*, by *convection currents,* and by *radiation.* Let us see how these three ways of heat travel work.

Have you ever noticed that the handle of a spoon left in a hot liquid soon becomes hot? If you place a frying pan on a stove, heat soon travels out to the handle. If you hold the end of an iron rod in the flame of a Bunsen burner, the other end soon becomes too hot to hold. The movement of heat through a substance is called conduction. Some substances are good conductors of heat; others are poor conductors. The common metals are good conductors. Air, cork, wood, paper, and asbestos are poor conductors.

If air or water is warmed it expands. As warm air expands it becomes lighter than a similar volume of cold air. The warm air rises above colder air below. If we heat a quantity of air in a room the warmed air rises to the top and the cold air falls to the bottom. As the cooler air is warmed, it in turn rises. The air which was first warmed cools off and falls back toward the floor. In this way currents of air are set up in the room. We say that the air circulates. The same thing happens with water in a tank, if the bottom of the tank is heated. We call these currents of air or water set in motion by a source of heat, convection currents. These flowing currents carry heat from place to place.

Convection currents can be shown in a beaker of water. *Sprinkle a bit of sawdust on the surface of the water in the beaker. Heat the water gently with a Bunsen burner. You can trace the currents by the circulation of the sawdust particles in the water.*

The air in a room and the things in it are warmed by convection currents. The warm air circulates through the room carrying heat with it. Much of the heat from a stove gets to other objects in a room by convection currents set up in the air of the room. Hot water circulates in a hot-



RADIANT HEAT CAN BE REFLECTED.

water heating system because convection currents are set up in the water in the system by the heat supplied in the boiler.

In nature, winds move because convection currents are set up in the atmosphere by the heat of the sun. Ocean currents are large convection currents.

Heat can also travel through space. This process of travel we call radiation. All of the heat on earth reaches us from the sun by this process. The atmosphere about the earth ceases to exist a comparatively short distance above the surface of the earth. The heat from the sun must travel a long distance through space before it strikes the layer of air around the earth. As a matter of fact, the air is a poor conductor of heat and checks the flow of heat from the sun to the surface of the earth. If it were not for this insulating blanket of air, we should all be burned by radiant heat from the sun.

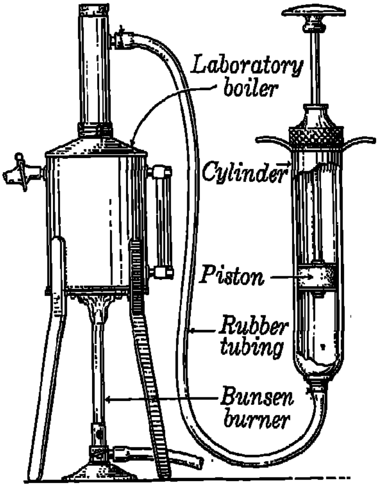
A hot stove, or a flame, or a red-hot iron, sends out heat by radiation. You can check this kind of heat transfer very simply. The ordinary electric lamp has had the air exhausted from the inside of the glass globe. We call such an empty space a vacuum. The filament in the lamp is a very thin metal wire. When the electric current is turned on, it is heated until it glows with a white heat. This heat passes through the vacuum in the globe to warm the glass. It takes only a few minutes for the globe to become too hot for anyone to hold.

Radiated heat can be reflected much as light is reflected. *Try placing a thermometer two or three feet away from a lighted Bunsen burner. Read the thermometer after five minutes. Set up a bright, polished piece of sheet metal in a half circle on the side of the burner away from the thermometer. Read the thermometer five minutes after this reflector is set up. What is the difference in the two thermometer readings?*

## 8. How can heat make an engine go?

Heat engines are possible because many substances increase in size when heated. Sometimes this change takes place very suddenly and with enormous force. *You can see this effect if you will partly fill a rubber balloon with cool air. Tie the balloon shut and warm it over a Bunsen burner. Keep the balloon far enough above the flame to avoid burning the rubber. Does the balloon expand? It is possible to make an engine which operates with hot air.*

If water at sea level is heated to 212° F. it changes into water vapor. The water vapor expands to occupy much more space than the water. This expansion takes place with great force. *You can get something of an idea of this force with the simple experiment suggested on page 112.*

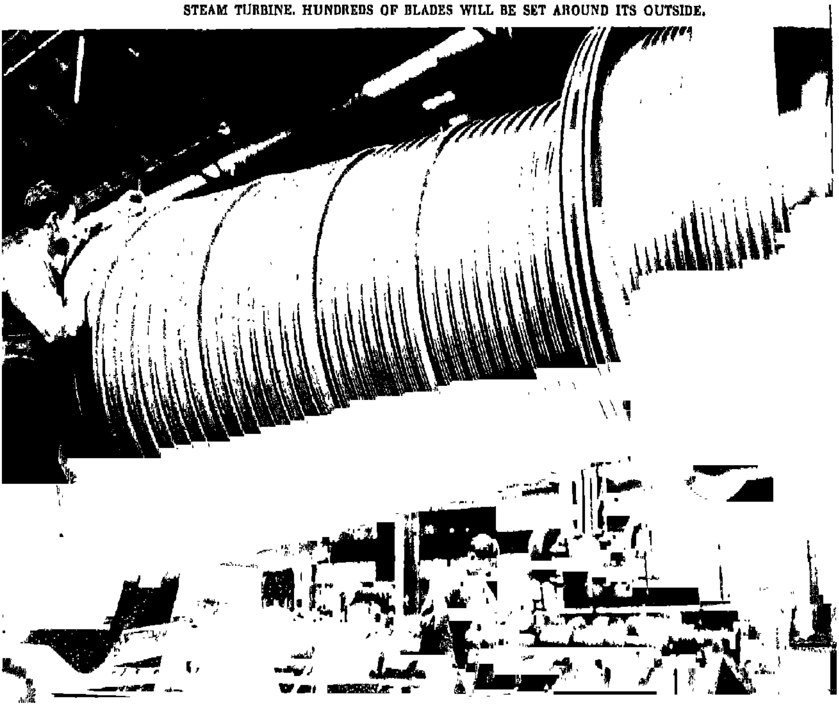


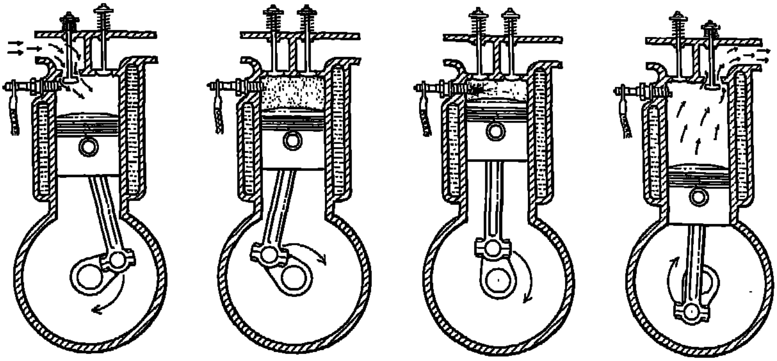
A BICYCLE PUMP ILLUSTRATES THE PRINCIPLE OF A STEAM ENGINE.

In a steam engine the force of the expanding steam is used to push a piston through a cylinder. *You can observe how this works with a bicycle pump or a simple large glass syringe. Take the pump apart to examine the piston in the cylinder. Put it back. Place some water in an ordinary copper laboratory boiler. Connect the steam outlet from the boiler to the stem at the bottom of the bicycle pump with a piece of rubber hose. If the pump has a check valve at the bottom connection, remove this valve. Otherwise use the syringe. Heat the water in the boiler until the steam begins to lift the pump handle. Remove the flame. What is going on in the pump?*

A steam turbine works by blowing jets of steam against the blades of a turning wheel. *Get a lid from a tin baking-powder can. With a pair of tin shears cut slots from the rim in toward the center. Make blades by twisting the pieces a half turn. Mount this by running a nail through the center and fasten-*

READY TO BE "BLADED" IS THE 50-TON PIECE OF STEEL TO SERVE AS THE HUB OF A STEAM TURBINE. HUNDREDS OF BLADES WILL BE SET AROUND ITS OUTSIDE.





*Intake* *Compression* *Power (Explosion)* *Exhaust*

THE OPERATION OF A SIMPLE GAS ENGINE IS SIMILAR TO THAT OF A GUN.

*ing the nail in a convenient support. A clamp on a ring stand will probably hold the nail satisfactorily. Arrange a rubber tube from the laboratory boiler so that steam can be turned against the blades of your wheel. Get up steam in the boiler. Turn the steam against the wheel.*

When some substances are burned in an enclosed space the rapid expansion of heated gases from the burning causes an explosion of great violence. You can burn a little black gunpowder in an open pan, and all that takes place is a quick harmless puff. The simplest tiny firecracker shows what happens when the burning is confined.

Any gun is truly a heat engine. The powder is burned in one end of the shell. The explosion of the confined hot gases pushes the bullet out of the tube of the gun. The powder is set on fire by a small cap in the base of the shell. The heat from the blow of the hammer, or bolt, of the gun is enough to set off the material in the cap. This starts the powder. In old-fashioned guns the powder was lighted by a burning fuse through a hole in the breech of the gun.

Gasoline engines work on the same principle as the gun.

Instead of powder they use a mixture of the gas from gasoline and air. The gas from the gasoline furnishes the fuel. The air furnishes the oxygen for the burning. The explosions take place in the cylinders of the engine. In the common gasoline engine the gas explodes in the cylinder above the piston. The explosion pushes the piston down. The series of explosions push down first one piston, then another. The piston rods are fastened to a crank shaft which is pushed round by the force of the explosions.

The gas in a gasoline engine is ignited by an electric spark which jumps across the points of the spark plugs that fit into the head above the cylinders. The spark plugs are connected through a coil to the electric battery of the car.

The gun and the gasoline engine differ from the steam engine. In the steam engine the fuel burns slowly in the firebox. The steam enters the cylinder behind the piston. The combustion takes place in the firebox, or furnace, under the boiler. In the gun or the gasoline engine the explosion takes place in the cylinder itself. The fuel is burned inside the working parts of the engine. For this reason such engines are called internal-combustion engines.

### THINGS TO DO

1. Ask some member of a scout troop to demonstrate fire-making with the friction of two sticks.
2. Make a report on the various ways in which people made fires before the invention of matches. What principles of fire-making are illustrated by each? Can anyone bring a flint and steel to show to the class?
3. Read what you can about the making of matches. Report on the making of matches for the class.
4. Ask the teacher to supply the class with a physician's thermometer. Check your own temperature and learn to

read the thermometer. A physician's thermometer should be disinfected after each use by dipping it in ethyl alcohol.

5. Try burning a very small amount of gasoline in an open pan out of doors on the school ground. Pour water in the pan while the gasoline is burning. Try a similar experiment and throw earth on the pan of burning gasoline.
6. Find out how a cigarette lighter works. Report and demonstrate for the class.
7. Ask a member of the local fire department to come to your class and make a ten-minute talk on fire-prevention.
8. You can show the transfer of heat along a metal rod by a demonstration. Get the solid part of a cheap, adjustable curtain rod. Measure two inches from one end. From there on mark six spaces at a distance of an inch apart. With a lighted candle place a drop of candle wax on each mark. In each drop of wax fix an air-rifle shot. Now support the rod by the opposite end with a ring-stand clamp. Heat the free end with a Bunsen burner or a candle flame. As the heat travels along the rod, the wax melts and the shots drop off.

## LIGHT AND ELECTRICITY TO INCREASE THE COMFORT OF LIVING

### 9. Why do hot things often make light?

We can heat a piece of iron until the heat radiated from it is felt a foot or so away. If the iron is heated to a higher temperature, it will glow red in the dark. At a still higher temperature the iron will be white-hot and give off more light. A bed of coals in the fireplace will glow in a dark room. If we add fresh fuel so that the fire blazes, there will be light enough to see about the room.

A candle flame will make some light in a room. The flame from an oil lamp will make a yellow light and considerably more heat than the candle. A gas lamp with a mantle will make a whiter light than without a mantle. The flame will also be hotter. The filament in an old-type carbon-filament electric lamp will make a yellow light. The metal filament in an improved electric lamp will glow at white heat and make a better light.

Light and electricity are radiated as energy just as heat is. The difference is in the wave lengths. When the temperature of a hot substance is increased, the rate of radiation is increased. If the temperature is raised high enough, the substance will give off light as well as heat. The temperature of a hot stove that cannot be seen in the dark is likely to be 400° to 500° F. A tungsten-filament electric lamp will have a filament temperature of about 2900° F. Scientists estimate the temperature of the sun at 6000° F.

*Try heating an iron rod in the Bunsen-burner flame until it glows. How much light will this make in a dark room? Be very careful in handling a hot iron rod.*

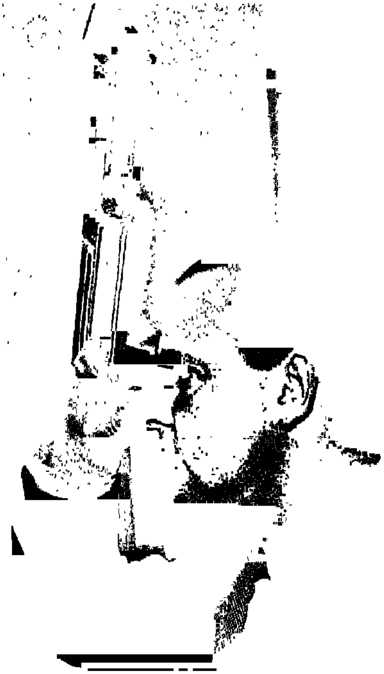
### 10. How do lamps make light?

Lamps make light by first making heat. If we make a lamp burn so that its temperature is very high, it will give

THIS PICTURE SHOWS AN ENLARGEMENT OF A NEW TYPE ELECTRIC LAMP FILAMENT. THE COIL MUST BE HEATED BEFORE IT GLOWS TO MAKE LIGHT.

off light as well as heat. In lamps we try to get a high temperature and produce a small quantity of heat. We keep down the total quantity of heat produced by a lamp by using a small amount of fuel or energy at any one time.

A candle flame reaches a high temperature. The amount of heat is small. If ten pounds of candle wax were burned at once, much more heat would be produced. Kerosene is used as a fuel for heaters. The kerosene is burned fairly rapidly to make a quantity of heat. In the kerosene lamp the temperature of the flame is high to produce light. The amount of fuel that is burned at any one time is kept relatively small.



A PERISCOPE WITH BINOCULARS MAY BE USED TO WATCH SCENES OVER THE HEADS OF A CROWD.

The electric lamp makes heat to produce light also. The filament in the lamp is very small. Its resistance to the current flowing through it is great. As a result the tiny wire is heated to a very high temperature. A bright light results. The wire is kept from being burned up because the air is pumped out of the glass globe and the globe sealed.

11. **What makes the reflection in a mirror?**

Light travels in straight lines. Do you remember the joke about the man that had a gun he could bend to shoot around corners? This becomes ridiculous in one way, because it is necessary to see around the corner too in order to sight the gun. You cannot see around a corner because light travels in straight lines. But you can see around a corner with mirrors!!

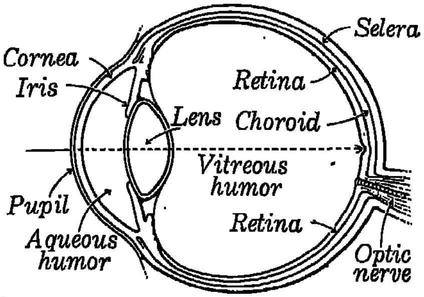
A bright polished surface will reflect light. The rays of light travel from the source of the light to the mirror in straight lines. The rays of light strike the surface of the mirror and are reflected at an angle to its surface. If a mirror is set at the proper angle you can see something that is coming from behind without turning your head. The rear-view mirror of an automobile illustrates this.

If two mirrors are used, they can be set at such an angle that it is actually possible to see around a corner. An instrument for seeing around corners is called a periscope. The arrangement of the mirrors and the paths of the light rays are shown in the figure on page 343.

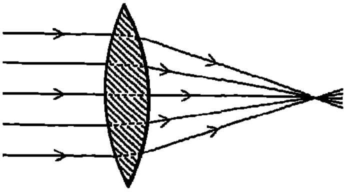
Many people are more interested in their own images in mirrors than periscopes. The image in the mirror is produced because the light that is reflected from the parts of the object seen, is turned back by the surface of the mirror toward the eye of the observer. The image will seem to be on a straight line drawn from the object itself, at a right angle to the surface of the mirror and as far behind the mirror as the distance that the object actually is in front of the mirror.

## 12. How do we see?

To understand how we see, it is first necessary to realize that nearly all objects reflect some light. A mirror reflects rays of light from its surface. Objects with rougher surfaces break up the rays and scatter them in all directions. Such scattered light is called *diffused light.* We see objects by means of the light reflected or diffused from their surfaces. This is true for all except completely black objects which absorb light rather than reflect it. We see black objects by



EXAMINE CAREFULLY THE DIAGRAMMED CROSS SECTION OF AN EYE.



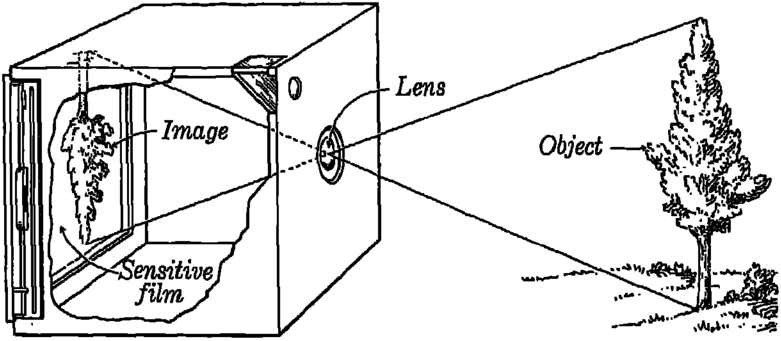
THE LENS OF THE EYE IS SHAPED LIKE A DOUBLE CONVEX LENS.

means of the light behind and around them which outlines their shapes, but not by any light reflected by them.

Of course we see with our eyes. A human eye is rounded. In front is an opening through which the reflected rays of light enter. This opening adjusts the amount of light entering the eye. The diaphragm which adjusts the size of the opening is the iris. When the light is bright, the opening is small. When the light is dim, the opening enlarges. Behind the central opening, the pupil, is the lens. The lens is shaped like a double convex (converging) lens. It is rounded at the center on both sides. Such a lens bends the light rays so that they come to a point and cross behind the lens.

The lens adjusts to objects at different distances from the eye by means of muscles which change the shape of the lens by flattening it or thickening it. The rays of light are drawn together so that a small image of an object in front of the eye is thrown on a network of nerves which serves as a screen at the back of the eye. This nerve screen is called the *retina.* The sensation of seeing is carried from the retina to the brain by the optic nerve which enters the eyeball at the back and from below.

You can better understand the effect of the lens of the eye in forming an image on the retina if you will try some simple experiments with a double convex (converging) lens. The following experiment will illustrate the principle: *Place a candle on a block of wood to serve as a base. Mount a sheet of white cardboard in a groove cut in another block of wood so that the card stands on edge. Set the lighted candle and the cardboard screen on a table two or three feet apart. Hold the lens between the candle and the screen. Adjust the distances until you get an image of the candle flame on the cardboard screen. Try changing distances. Does the size of the image change? The lens of the eye has the same effect as your double convex lens in forming an image on a screen behind it. Your candle image will be upside down on the screen as the light rays cross between the lens and the screen. This is true for the image on the retina of the eye also.*



HOW IS THE IMAGE FORMED IN A CAMERA?

### 13. How does a camera take pictures?

A camera works somewhat like the human eye. A camera is a black light-tight box with a lens in an opening in front. In front of the lens is a shutter that can be quickly opened and closed. The opening in the center of the shutter can be adjusted to the amount of light. In this way it corresponds to the iris of the eye. At the back of the box is a light-sensitive plate or film. The camera is adjusted in its distance from the object to be photographed so that an image is formed on the film when the shutter is opened. Cameras with bellows can be adjusted without moving the whole camera back and forth.

The film is coated with an emulsion in which there is a silver salt that is very sensitive to light. The light affects the silver salt in varying degrees, depending upon the amount of light reflected from the object that is photographed. After the film is exposed, it must be treated with other chemicals to fix the image on the film. This treatment must be done in a dark room with a special ruby light. If the film is exposed to the light before it is treated, the whole film becomes black and the image does not show.

Prints can be made from the developed film by placing the film over light-sensitive paper, and exposing this to the light for a short interval. These prints must also be treated in special chemical baths.

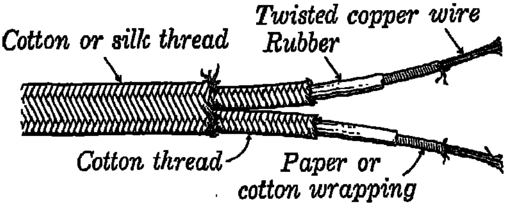
You can understand a camera better if you will get from the science storeroom a simple box camera with a back that can be removed. *Set a lighted candle in front of the lens of the camera. Remove the back and see if you can get the candle image on a piece of white paper held near the back of the camera. Remember that the shutter must be opened for light to pass through the lens. Try operating the shutter and the adjustment of the opening in it.*

### 14. How can we have heat and light from electricity?

The electric current which we use in most homes is produced in a central station by large generators that are turned by steam or water power.

As with heat, some substances are good conductors of electricity and others are poor conductors. The common metals, water, the earth, and our own bodies are conductors of electricity. Glass, porcelain, rubber, dry silk, dry paper, and dry cotton are poor conductors. The poorest conductors are often used as insulators to prevent electricity from being carried to some place where it is not wanted.

Of the metals silver is the best conductor of electricity. However, silver is an expensive metal for electric wiring. Copper is a very good conductor, and less expensive. The wires carrying the current into our homes from the power station and the connecting wires in the house are made of copper. These wires are wrapped with insulating materials, and held away from touching the house materials bv insulators.

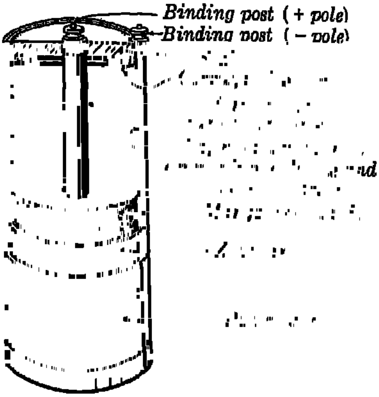


BOTH GOOD AND POOR CONDUCTORS OF ELECTRICITY ARE USED IN A LAMP CORD.

Some of the metals which conduct electricity offer more resistance to the current than others. A copper wire offers less resistance than iron wire of the same length and size.

The resistance of a wire carrying an electric current is something like the resistance of a pipe to the flow of water passing through it. The smaller the diameter of the pipe the greater its resistance to the water passing through. The longer the pipe of a given size, the greater is the total resistance to the water passing through it. For wires carrying an electric current, a wire of small diameter has greater resistance than a larger wire of the same kind. A long wire has a greater resistance than a short one of the same diameter and metal.

When an electric current is forced through a wire of high resistance, the wire becomes hot. The resistance of the wire changes the energy of the electric current into heat.

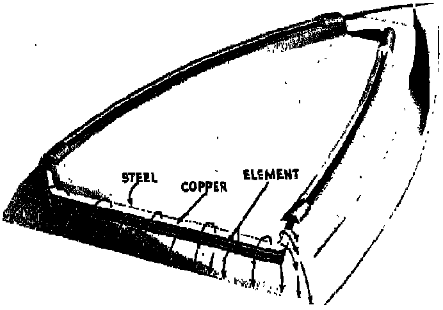


A DRY CELL CAN PRODUCE SMALL AMOUNTS OF ELECTRIC CURRENT.

You can try this very simply with a common dry cell and a piece of small-sized copper wire. A dry cell is another device for producing small amounts of electric current. It consists of a zinc can filled with a paste of ammonium chloride and certain other materials packed around a carbon rod. The chemical action of the ammonium chloride with the zinc sets up an electric current between the zinc and the carbon rod. The current is taken off from small brass bolts, one on the zinc and one on the carbon rod. The zinc is the negative pole of the cell and the carbon is the positive pole.

*Fasten a six-inch piece of bare copper wire of the size called magnet wire to the positive pole of a cell. Hold the other end of the wire against the negative pole. Be careful that you do not burn your fingers. As soon as the wire becomes hot, break the connection. Keeping a dry cell connected through a short piece of wire for any great length of time ruins the cell.*

A kind of wire called nichrome has high resistance to an electric current. If current from the house mains is sent through such a wire, it will become red-hot and throw off considerable heat. Common electric heating appliances are made with nichrome elements. In many appliances the wire is curled in long coils. The coiling simply increases the length of the element. Remember that a long wire has higher resistance than a short one of the same kind and size. Some toasters and electric irons use a flat wire wound zigzag back



THIS PICTURE SHOWS THE LOCATION OF THE HEATING ELEMENT OF AN ELECTRIC IRON.

and forth about a sheet of mica. The zigzagging increases the length. The mica is an insulator for both heat and electricity.

You will remember that if a heated substance reaches a high enough temperature, it glows and makes light. In the electric lamp a very small tungsten wire is used. This wire has a high resistance to electricity. The small diameter of the filament increases its resistance. The wire is encased in a glass globe which has had the air removed. Removing the air keeps oxygen away from the small-sized filament so that it does not burn up. As the electric current passes through this small wire in the lamp it becomes so hot that it glows and produces light. Some kinds of electric lamps are filled with nitrogen. Filling the lamp with this gas serves the same purpose as exhausting the air from the globe. The heated tungsten does not unite with the nitrogen.

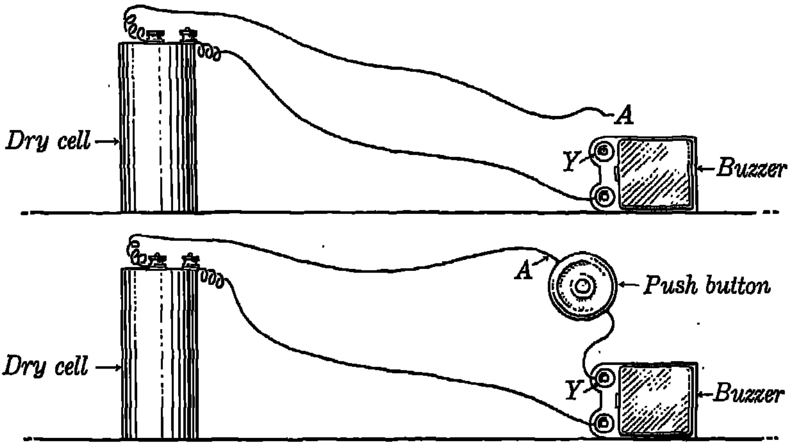
## 15. How does a switch control electric current?

You know that when you wish to have light to read by you push a button, or turn a knob, and the electric lamp gives light. What does the button or knob do? The push button is a kind of switch. For an electric current to pass through a conductor there must be a complete circuit. This means there must be a path through the generator and the wiring, through the lamp and back to the generator. If this path is broken anywhere, there will be no current. A switch opens and closes a gap in the circuit.

*Set up a very simple circuit like that in the diagram with* *a dry cell and a buzzer. If you touch the loose end of the wire at A to the post of the buzzer at Y, the buzzer sounds. If you remove the wire the circuit is broken and the buzzer ceases. Fasten the wire to the post at Y. The buzzer goes all the time. Now take a pair of pliers and cut the wire in the circuit at any point. What happens?*

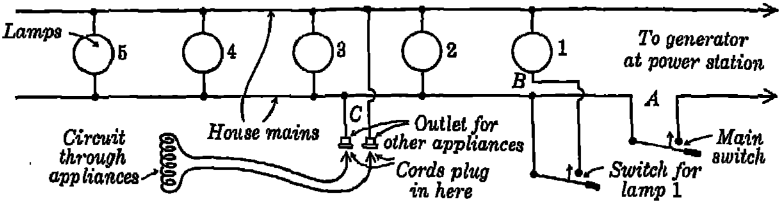
*Get a simple push button from the storeroom. Take it apart to see that when you push on the button you press two metal plates together. See how these plates are fastened to the wires that run out of the button. Connect the push button in a circuit like that in the figure. Connect one side of the button to the loose end A. With another small piece of wire connect the other side of the button to the post Y. Push on the button.*

Several lamps can be connected to the same circuit if the circuit is wired like that in the diagram on page 338. If a switch is placed at A, it will turn all of the lamps in the circuit on and off. If a switch is placed at B, it will turn lamp



FOR AN ELECTRIC CURRENT TO PASS THROUGH A CONDUCTOR THERE MUST BE A COMPLETE CIRCUIT. THIS MAY BE DEMONSTRATED BY CONNECTING WIRE, A BUZZER AND A DRY CELL AS SHOWN number 1 on and off when switch A is closed. This will illustrate how lamps in your house circuit can be turned on and off in the same circuit.

If you wish an electric outlet for operating other appliances, it can be set into the circuit like the one at C. Plugging in any appliance closes this part of the circuit through the wiring of the appliance. *You can try this by wiring a dry cell to an ordinary electric outlet like that used for house wiring. See the diagram. Cut two feet of ordinary electric cord to which a plug is attached. Unwind six inches of the free ends of the cord. Remove the insulation from the ends and fasten these to the two posts of a buzzer. Plug the buzzer cord into the outlet connected with the dry cell.*


Lamps
5
4
3
2
1
To generator at power station
B
A
C
Outlet for other appliances
House mains
Circuit through appliances
Cords plug in here
Switch for lamp 1
Main switch

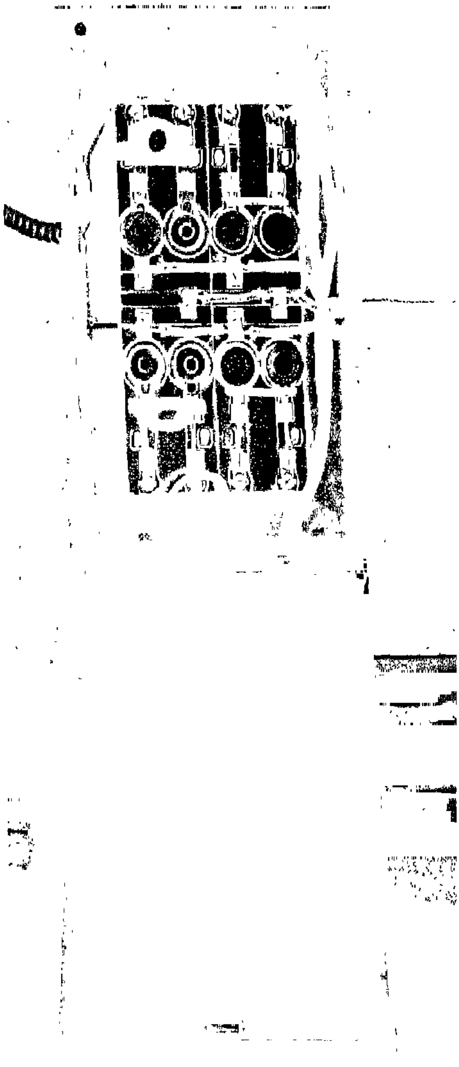
AN ELECTRIC OUTLET FOR OPERATING ANY ELECTRIC APPLIANCE CAN BE SET IN THE CIRCUIT LIKE THE ONE AT C.

An electric current follows the shortest path to complete a circuit. If bare wires become crossed, the current follows the shortest path. This crossing at some place in a circuit is called a *short circuit. Connect your buzzer circuit. Start the buzzer. Lay a piece of bare wire or the shank of a screw driver across the two posts of the buzzer while the button is closed and the buzzer is going. What happens?*

The earth is a good conductor of electricity. If a main wire carrying a current is broken and falls to the ground, the current becomes shorted to the ground. We say the current is *grounded.* Your own body is a conductor. Do not catch hold of broken and hanging wires near a power line. You may form the connecting link between a power line and the ground. Many people have been killed or seriously injured by taking hold of a "live wire."

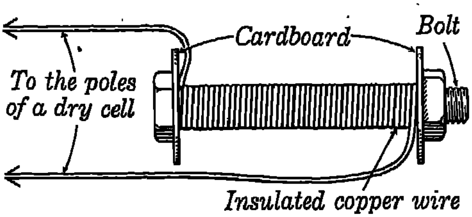
A short circuit in house wiring sometimes makes considerable heat in the wiring. This might burn the house or burn up some valuable appliance. For this reason fuses are placed in all house circuits near the point where the current enters the house from the mains. See whether you can locate the fuse box in your own house.

A fuse is a plug across which there is a short length of a soft metal. If the resistance in the house line gets too great, either through a short circuit or an overload of appliances, this soft metal melts in two. A fuse can be replaced by simply unscrewing the old one and screwing in a new one. The main switch for the house circuit should be thrown off before replacing fuses.



THE FUSE BOX FOR YOUR HOUSE WIRING LOOKS SOMETHING LIKE THIS ONE. BE SURE TO OPEN THE LARGE SWITCH BEFORE TRYING TO REPLACE FUSES.

When a fuse burns out the trouble should be located and remedied. Something else is



A CURRENT PASSED THROUGH A COIL OF INSULATED WIRE AROUND AN IRON CORE MAKES AN ELECTROMAGNET.

wrong or otherwise the fuse would not burn out.

Do not try to repair fuses with a penny in the socket. You may start a fire if the thing that caused the fuse to burn is not repaired.

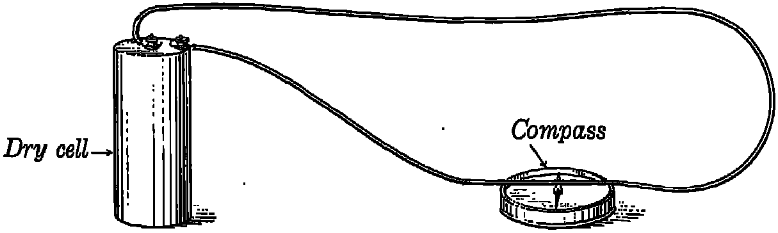
### 16. How can an electric current make a magnet?

A simple magnet is a piece of iron which will attract or pick up other bits of iron. Magnets are sometimes found in nature. Ancient peoples called them lodestones.

A compass is a magnet mounted so that it will swing freely about a pivot. The compass points north toward the magnetic north pole of the earth. Usually a compass needle is blued on one end and left light on the other. The blued end points north and the other end points south. The north pole of one magnet will attract the south pole of another. The north pole of a magnet will push away the north pole of another. This is also true for two south poles.

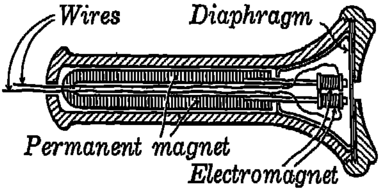
*Attach a wire to a dry cell. Bring this wire carrying a current over a compass needle. Observe that the compass needle turns. A wire carrying current behaves like a magnet.*

A magnet can be made by winding a coil of insulated wire



A WIRE CARRYING A CURRENT AFFECTS A COMPASS AS A MAGNET DOES.

around an iron core and then passing a current of electricity through the coil of wire. As long as the current passes through the coil, the iron is a magnet. Such a magnet is called an electromagnet.



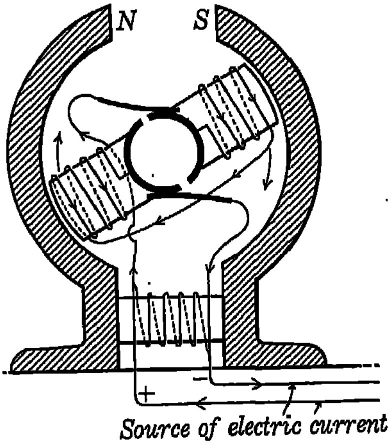
THE TELEPHONE RECEIVER USES AN ELECTROMAGNET.

*You can make an electromagnet by winding several turns of insulated magnet wire on an ordinary carriage bolt. Connect this through a switch with a dry cell. Close the switch and try picking up small nails with your magnet. Open the switch while the nails are clinging to the magnet. What happens?*

## 17. What are some machines that use electromagnets?

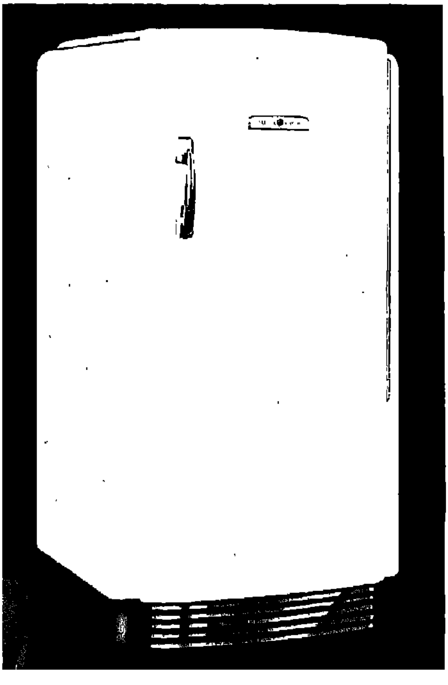
Most electric appliances that move use electromagnets to produce the movement. This is true of the doorbell, buzzer, and the simple telegraph instrument. *Examine these appliances and find the magnets. Connect them in circuits with switches and see how the magnets in each work. Could you build a buzzer?*

The telephone receiver also uses an electromagnet to move the diaphragm which makes the sounds which you hear. *Get a telephone receiver from the science supply room. Unscrew the ear piece. Remove the thin metal diaphragm. You*



MOTORS MAKE USE OF ELECTROMAGNETS.

THESE HOUSEHOLD APPLIANCES ARE OPERATED BY ELECTRIC MOTORS.

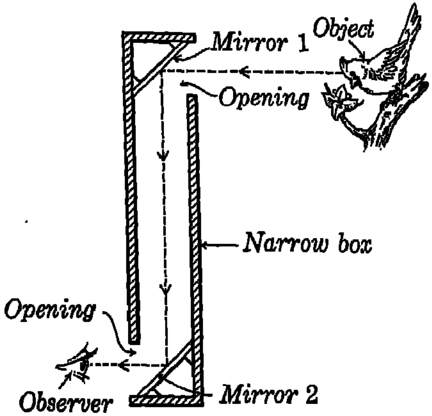


*will see small electromagnets just beneath. Replace the diaphragm without screwing on the ear piece. Connect one strand of the receiver cord to one pole of a dry cell. Touch the tip of the other strand to the other pole of the dry cell. What happens? Repeat this.*

Motors also use electromagnets to make them turn. When an electric current is sent through a coil of wire suspended between the poles of a magnet, the coil will turn. *Find a large horseshoe magnet. Make a coil of several turns of insulated magnet wire. Leave long ends from the coil. Tie the coil at the top with a piece of strong, silk thread. Hang the coil from a ring stand by a silk thread so that the coil hangs between the poles of the horseshoe magnet. Connect one of the loose ends of the coil to the pole of a dry cell. Touch the other loose end to the other pole of the cell. Does the coil move? Try again.*

The revolving magnet in a motor is called the *armature*. Sometimes the armature consists of several magnets. The fixed magnet is called the *field magnet.* In commercial motors both the field magnet and the armature are *electromagnets.*

The current gets into the coils of the motor through brushes of metal or carbon which slip on a smooth ring connected to the ends of the coils. Some modern motors are built without brushes to avoid radio interference.



FOLLOW THIS DIAGRAM IN CONSTRUCTING A SIMPLE PERISCOPE.

*Get from your science storeroom a small motor that can be taken apart. Operate it. Examine the parts carefully. See if you can make a diagram of the parts and explain how the motor works.*

All of the motors used for household appliances, such as fans, refrigerators, vacuum cleaners, washing machines, and food mixers work on this simple principle. Larger motors are used to turn many of the machines used in manufacturing all kinds of goods. Trains that are operated by electricity are pulled by great motors.

### THINGS TO DO

1. Break open an electric lamp carefully and examine the filament.
2. Try making a simple periscope by setting mirrors in a long box made of strips of wallboard glued together. See the diagram above.
3. Ask someone to bring in an old electric iron that is of no further use. Open it and examine the filament.

4. Make an electromagnet. See if you can make a buzzer of your own after examining carefully the school buzzer.
5. In some of the books in the reading list will be found directions for making small motors. Find a set of directions in one of these books and make a motor.
6. Make and wire a burglar alarm, using a doorbell for the alarm. Make a rough diagram of your wiring plan and have it approved by the teacher.
7. Try making a wet cell by using a strip of zinc and a carbon rod set in a glass jar in a strong solution of ammonium chloride. The carbon can be taken from an old dry cell. Will your cell operate a buzzer?

### UNIT ORGANIZING ACTIVITIES

1. Make an exhibit of foods which would be recommended for people doing hard labor in a cold climate.
2. Make an exhibit of foods for people working in offices in warm weather.
3. Make a set of rules for safety from fire at home.
4. Make a set of camping rules for fire prevention.
5. Examine the arrangement of dampers and checks in the home-heating plant. Make a diagram to show their location. If the heat comes from an automatic gas or oil burner, diagram the air flow through the fire chamber.
6. Ask some member of a camera club to demonstrate his camera for the class.
7. Set up a lamp circuit with switches using flashlight lamps. Power can be taken from a group of flashlight cells. Ask the teacher to show you how to connect these.

### SOME THINGS TO REMEMBER

1. A combustible substance, heat raised to a kindling temperature, and oxygen are all necessary for burning.
2. The oxygen for burning comes from the air.
3. Burning, or combustion, is the combining of a substance

with oxygen. Another name for the process is oxidation.

4. Our bodies are warmed by the slow oxidation of foodstuffs in the body tissues.
5. Proper clothing keeps the heat of the body from escaping too rapidly and so keeps us warm.
6. The common metals are good conductors of heat.
7. Air, paper, wool, silk, cork, and wood are poor conductors of heat.
8. Fires can be prevented by controlling any one of the conditions necessary for burning.
9. Most fires can be extinguished by keeping air away from the fire.
10. A fire in a person's clothing can be smothered with a blanket, rug, or heavy coat.
11. Gasoline fires can be extinguished with earth or sand.
12. Stoves or furnaces have a draft below the grate to permit air to enter through the fire. The check damper is in the smoke pipe. It checks the flow of air up the flue.
13. Air must be mixed with the gas in a gas burner.
14. Temperature is measured with a thermometer.
15. The freezing point of water is 32° on the Fahrenheit scale.
16. The boiling point of water is 212° on the Fahrenheit scale.
17. Normal body temperature of a human being is 98.6° F.
18. Heat can be carried from place to place by conduction through a substance, by convection currents in air or water, or by radiation.
19. If the temperature of a heated substance becomes high enough it gives off light by radiation. Most substances expand with the heating. This expansion takes place with great force.
20. Light travels in straight lines.
21. We see by the light that is reflected by objects.
22. Light which enters the eye is collected by the lens and

the image is focused on the retina, a network of nerves.

23. A camera takes pictures on the same principle that the eye forms images on the retina.
24. A wire carrying an electric current offers resistance to the passage of the current.
25. If the resistance is high enough, a wire carrying an electric current becomes hot. When the heated wire reaches a high enough temperature it gives off light.
26. A coil of wire suspended in the field of a magnet will turn when an electric current is sent through the coil. This is the principle of the electric motor.
27. An electromagnet can be made by winding a coil of insulated wire around an iron core and then sending an electric current through the coil.
28. There must be a complete circuit for an electric current.

### BOOKS TO READ

Adams, J. H. *Harper's Electricity Book for Boys.* Revised. Harper & Brothers.

Darrow, F. L. *The New World of Physical Discovery.* Harper & Brothers.

Good, F. F. *Laboratory Projects in Physics.* The Macmillan Company.

Lunt, J. R. *Everyday Electricity.* The Macmillan Company.

Lynde, C. J. *Science Experiences with Home Equipment.* International Textbook Company.

Meister, Morris. *Energy and Power.* Charles Scribner's Sons.

Meister, Morris. *Magnetism and Electricity.* Charles Scribner's Sons.

Neblette, C. B., Brehm, F. W., and Priest, E. L. *Elementary Photography.* The Macmillan Company.

Watkins, R. K., and Bedell, R. C. *General Science for Today.* (Revised.) Chapters 14, 15, 17, 18. The Macmillan Company.

# UNIT TEN

# UNIT TEN

# Useful Plants and Animals

## WHAT THIS UNIT IS ABOUT

The work of scientists has made it possible to control some parts of the world in which we live. We have seen that those plants and animals that are better adapted to the conditions of the environment in which they live get along better than those plants and animals that are less well adapted. This is just as true for human beings. Men are widely distributed over large parts of the earth. One of the things that makes this possible is the fact that men have been able to adapt themselves to a great variety of food substances and a great variety of ways of getting food. What do Eskimos eat? How do they get food? What do African pygmies eat? What do South American Indians use for food? How does an apartment-house dweller in New York City get his food? Where does it come from?

One of the reasons that human beings have been able to live in a variety of environments is that they have been able to think out solutions to problems, to make discoveries and inventions. Sometimes we say that where a man has been unable to adapt himself to his environment, he has changed or adapted the environment to fit his needs.

For example, in a cold climate instead of depending upon growing a heavy coating of hair after many generations, or hibernating as the bears do, human beings have learned to make warm clothing, build shelters, and to heat their homes. That is, human beings have gained enough control of things in the world to build a more suitable environment for themselves.

This attempt at control of our own environment has been illustrated by the building of machines, and by the use of heat, light, and electricity as sources of energy, or as means of making our living more comfortable and attractive.

Along with the attempts to gain control of the physical environment, men have for a long time tried to make use of plants and animals for their own purposes. This has been done in three ways. First, we have made use of the plants and animals as we have found them. We have simply used what we could find, as in eating wild fruits, fishing in the nearest stream, or hunting game in the forests. Secondly, we have tried to keep a supply of plants and animals ready for any daily use. Finally, we have tried to produce changes in some kinds of plants and animals to make them more nearly fit our ideas of greater usefulness. How different is a Percheron draft horse from the wild native ponies of the highlands of Asia?

In this unit we shall try to understand some of the ways in which human beings have gained control of plant and animal life and some of the reasons why we have sometimes failed to make good use of the plants and animals about us.

# Useful Plants and Animals

## UNIT PROBLEMS

1. What are useful plants and animals?
2. What are domesticated plants and animals?
3. How have plants and animals been changed under domestication?
4. How are changes in domesticated plants and animals produced?
5. Why do we need to conserve our plant and animal life?
6. What is being done to prevent the extermination of wild life?

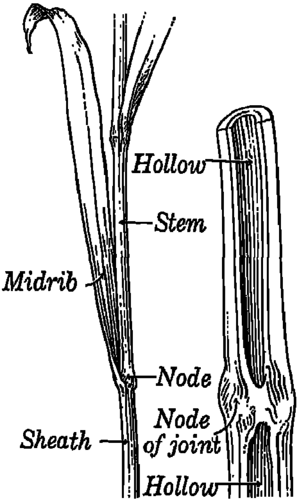
## USEFUL PLANTS AND ANIMALS

### 1. What are useful plants and animals?

If you imagine a country with undisturbed plants and animals in which no human beings have attempted to live, you could say that any one plant or animal is just as useful as another. Under natural conditions, or in a perfectly wild country, there is no such thing as a useful plant or animal. Any plant, that in its struggle with other plants, can get sunshine, air, water, and minerals enough, will live for a time. Any animal that can get enough food, some shelter, and can escape its enemies, will live for a time. There is no question of use, since there are no men to disturb the balance of nature.

The idea of use applies only when we as human beings consider the things that can be turned to our own advantage. A useful plant is one that can serve as food for human beings, or one from which we can get materials for clothing, or that will supply materials for homes, or possibly one that we enjoy for beauty of form or color.

In the same way a useful animal is one which can be made to furnish meat or milk for human beings, one that can be used as a beast of burden, one whose hide can be used as clothing, or one that makes an interesting pet, companion, or guardian.



THE GRASSES HAVE LONG PARALLEL VEINED LEAVES.

You can readily see that usefulness depends much upon the climate and general environment. Some plants and animals are useful in one place for some people and not at all useful in other places and under different conditions. Indeed, plants that are useful in some conditions may become nuisances under others. As you have seen in the definition of weeds, page 175, a plant can be useful in one field or garden and a weed in another. Sweet violets find a place in many gardens and are commonly sold by florists. The plants spread rapidly by rootstocks and can easily become a nuisance in a perennial flower garden where other plants are preferred during the summer.

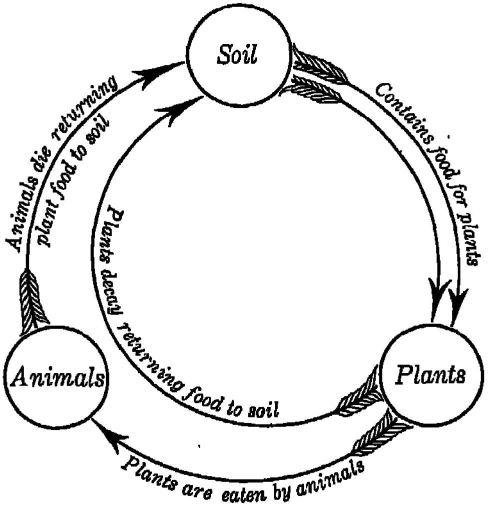
What has just been said of plants is also true of animals. Rabbits are hunted as game and their relatives, the domestic hares, are kept as food animals. And yet, to many farmers the common rabbit is a serious animal pest destroying many kinds of farm and garden crops. Rats and mice are continually destroyed as destructive and disease-carrying enemies of mankind. And yet, the white rat is a useful animal for many kinds of laboratory experiments. In India tamed elephants are very useful beasts of burden. Can you imagine how useful an elephant might be to you if you had to care for one in the back yard and provide the necessary amount of fodder?

When people live under very simple conditions and depend for a living on the things that grow wild, a useful plant is one that can be found to produce food or something else needed in daily living. Native nuts and fruits make good illustrations. In this connection you might think of such things as wild strawberries, blueberries, wild currants, plums, black walnuts, hickory nuts, hazel nuts, and native pecans. What are the wild plants that are still used as sources of food in the country about your home? *Make a list for the school bulletin board. Perhaps you can make a collection for school exhibit.*

Perhaps the best illustration of our dependence upon native plants is to be found in the lumber which we use for building purposes. Almost all of the world's supply of lumber for all kinds of uses comes from native or wild trees. Just within recent times have people begun to plant some trees to insure a lumber supply in the future. What native trees are used for lumber and furniture in your state?

The usefulness of native wild animals is well shown by the life of the American Indians before the coming of Europeans. Much of the food of the Indians came from the animals captured in hunting. Nearly all of the clothing of many tribes came from the skins of animals. The Plains Indians lived in homes (tepees) made of poles and skins. Useful animals to the Indians were deer, buffalo, beaver, turkeys, the smaller game birds, and the fishes that could be taken from the neighboring streams. What animals hunted by the Indians are still to be found wild in the country near your home? *Make a list of these for the classroom bulletin board.*

When natural conditions are undisturbed by human beings, the living things in any one place adjust themselves to the amount of water and sunlight available and to the soil of the particular place. Almost any plant produces more seed than can grow and live in the place where the parent grew. Most animals can in a few years produce more young than can be supported in the place where the parents live. This means that only a few plants and animals can continue to live in any one place. Those that do live adjust themselves to the food and water supply, the soil and climatic conditions of the place. The plants that can grow make food for a limited number of animals. Part of the animals kill some of the others for food, so that from year to year only a part of any one species of animals live. Scientists speak of the *interdependence* of all kinds of living things. The adjustment of different kinds of plants and animals to one another and to the environ-


Soil
Contains food for plants
Plants
Plants are eaten by animals
Animals
Animals die returning plant food to soil
Plants decay returning food to soil

PLANTS PROVIDE THE FOOD SUPPLY FOR ANIMALS, AND ANIMALS HELP TO MAINTAIN THE SOIL'S FERTILITY.

ment in any one place is sometimes called the *balance of nature. Can you name any instance in which the balance of nature has been disturbed?*

Sometimes an aquarium with water plants and animals is kept going as a balanced aquarium. When such an aquarium is nicely balanced, a glass plate can be placed over the top and the whole left alone for weeks without adding water. Food is provided for the animals by the plants and very small creatures in the water. Carbon dioxide and oxygen are interchanged between the plants and animals. Can you explain how? *Suggestions for starting an aquarium can be found on pages 137-138.*

A terrarium is a similar closed jar in which there is a balance of living things. The terrarium uses land plants rather than water plants. In this a balance of moisture is kept so that water needs to be added only at rare intervals. Can you set up such a jar?

Human beings, especially civilized human beings, disturb the balance of nature. When many plants are taken for human food in one place, the balance is disturbed. If more animals are killed by men than would naturally be killed, the relationships of living things are changed. If forest trees are cut down for lumber the whole nature of life in the place where the forest once stood is changed. You can most easily see this by visiting a wooded section of country and then visiting a near-by similar section where the trees have all been cut.

If you will think about the effects upon the life of a region, you will see that the draining of swamp lands and the irrigation of dry lands also affect the balance of nature. Can you explain how such changes affect the native plants and animals?

In places where there are only a few human beings, and these have very simple tools and weapons, the effect of men upon the balance of nature is small. We can almost say that the men fit into the natural conditions and become a part of them. This is true for many savage tribes living under jungle conditions today. It was true of many Indian tribes in our country before the time of Columbus. Many Plains Indians hunted buffalo. These Indians had no horses or guns before the coming of white men. They could kill only a few buffalo at any one time. These Indians moved from place to place as they could find better hunting. Under such conditions the Indians probably had little effect upon wild life. It would seem that buffalo could have continued to exist for a very long time.

Human beings are not strong enough to have a great effect upon natural conditions until they have learned to use tools and inventions of various kinds.. Soon after white hunters began to hunt buffalo with guns and horses, the buffalo were almost completely destroyed.

The Indians hunted for the food and hides that they could use for themselves. The white hunters hunted for hides to be sold on eastern markets. Often the meat was left to decay when the animals were killed. With this last kind of hunting it did not take long to destroy buffalo much more rapidly than they could reproduce.

### 2. What are domesticated plants and animals?

If food must be found from day to day by gathering wild grain, nuts, or berries, or by hunting and fishing, the supply is none too sure. Most people who depend upon such foods move from one place to another as they can find better supplies. Can you imagine going out into a wild country with no modern tools and no gun to get your food from whatever you can find?

Before the beginning of our records in history, someone discovered that it would be better to plant grain and fruits and live in one region. Or someone else discovered that animals could be tamed and kept in herds and so make it unnecessary to hunt continually.

When these things happened people began to have fixed homes and a surer food supply. The cattle herders continued to move with their herds to wherever they could find good supplies of grass. The growers of plants settled near their fields and built towns. Later some cattle were fed on domesticated grasses and grains and in some places the herdsmen settled down in permanent homes too. At an early stage of what we call civilization man learned to raise plants and animals and care for them. We call those plants and animals that have long been grown especially for human use *domesticated plants and animals.*

Today we depend for our ordinary foods almost entirely upon the domesticated plants and animals. This is also true for much of our clothing and many other things which we use daily. Nearly all of our domestic plants and animals came from wild ancestors that were selected and grown by our early forefathers. A few of those which we now grow have been produced by experiments in breeding, and are unlike any wild ancestors that we know.

*Make a list of those things you can see about your own home which come from plant or animal materials. For which of these things do we depend upon wild plants or animals? Does silk come from a wild or domesticated moth? Can you verify your answer? How does your morning newspaper depend upon plant or animal materials? Is the source wild or domestic?*

The grain plants or cereals produce the greatest quantities of foods for both men and domestic animals. The cereals are grasses. Wheat, rice, and corn are said to have made three great civilizations possible because these grains furnished the bulk of the energy-producing food used by the people in three distinct parts of the world. Rice has long been the chief food eaten by the people in Eastern Asia, China, Japan, and the Philippine Islands. Wheat was widely used in western Asia, Northern Africa, and Europe long before the birth of the United States. Corn was used by the Mayas, Aztecs, Incas, Peruvians, and Guatemalans who established early civilizations on the American continents. Important cultivated grasses are wheat, rice, corn, sorghum, sugar cane, oats, rye, and barley. The seeds of grasses are starchy with the embryo, or young plant, at one end. It is this starch stored in the seeds that makes the grasses such important food plants.

During the years 1936-1937 four of the seven principal crops grown in the United States belonged to the grass family. Corn was the most valuable farm crop, while hay, including hay from other plants than grasses, wheat, and oats were given third, fourth, and fifth places respectively.

Corn is as distinctly a gift of the western world as wheat is of the eastern world. There is a large section in our so-called Middle West that is called the corn belt. Iowa, Illinois, Nebraska, Missouri, Ohio, Minnesota, and Indiana are the principal corn-producing states in which more than half of the world's corn is grown. These states have the kind of soil, and the rainfall and temperature conditions necessary for growing this important crop, as well as farming systems that use great quantities of the grain in feeding livestock.

Most of the corn produced within the United States is fed to livestock to be slaughtered for meat. Nearly half of the corn grown in the corn states is fed to hogs, and about one fifth is fed to cattle and sheep, while about one fourth of the crop is fed to horses, mules, and poultry. The remainder is used for human food, and for industrial purposes. Many trainloads of corn are used in the manufacture of corn syrups, salad oils, and cornstarch. Should our supplies of gasoline to be used in automobiles become exhausted, we could manufacture fuel alcohol from corn.

The early settlers in the American colonies brought wheat with them. The first wheat grown in the United States was planted in Virginia in 1618. Wheat is not a crop of warm, humid regions. Most varieties of wheat do better where it is somewhat cool and where the rainfall is not too great. For this reason the plains of the northwestern United States and of Canada east of the Rocky Mountains have become one of the greatest wheat-producing regions in the world. Russia, Canada, India, and Argentina also produce wheat on a large scale.

Most of the wheat is made into flour to be used as the foundation for all of our bakery products. Bran, shorts, and middlings, used as stock foods, are by-products of the flour mills.

Rice is a peculiar grass in that it usually requires water in large amounts. The typical rice is a lowland rice that grows in marshes. Water stands on the fields during much of the growing season. A type of rice called upland rice is grown on drier fields, much as wheat is. Besides requiring such an extraordinary amount of water, lowland rice also requires a higher temperature than most of the cultivated grasses with the exception of sugar cane. Rice is not grown as extensively in the United States as corn, wheat, and oats. It is an important crop in Louisiana, Texas, California, and Arkansas. It is the most important cultivated grain crop in China, India, and Japan. The seeds of this grass are more important to Oriental peoples than wheat and corn are to the people living in other parts of the world. Can you think of two reasons that prove the last statement true?

Oats is another important cereal crop in the United States. The states that produce corn also produce most of the country's oats. The seeds furnish an important feed for horses and are sometimes fed to other kinds of livestock. With the use of fewer horses and a greater use of tractors, oats have become less important as a farm crop. The oatmeal that is widely used on our breakfast tables is made from the grain or seeds of the oat plant. Recently a chemical substance, called *furfural,* has been produced from oat hulls. This is widely used in making such objects as radio panels, knobs, combs, and furniture trim. This may lead to an increased growing of oats.

Hay was valued more highly than wheat or oats in a study made of the crops grown on American farms during 1937 and 1938. Nearly all of the states grow some of the hay

THE STEMS OF THE SUGAR CANE ARE FILLED WITH THE SWEET JUICE THAT IS MADE INTO SUGAR.

crops which may be grasses such as redtop and timothy, or legumes such as clover and alfalfa. The entire plant is cut and dried for hay, which is a necessary part of the food ration of nearly all farm animals with the exception of poultry.

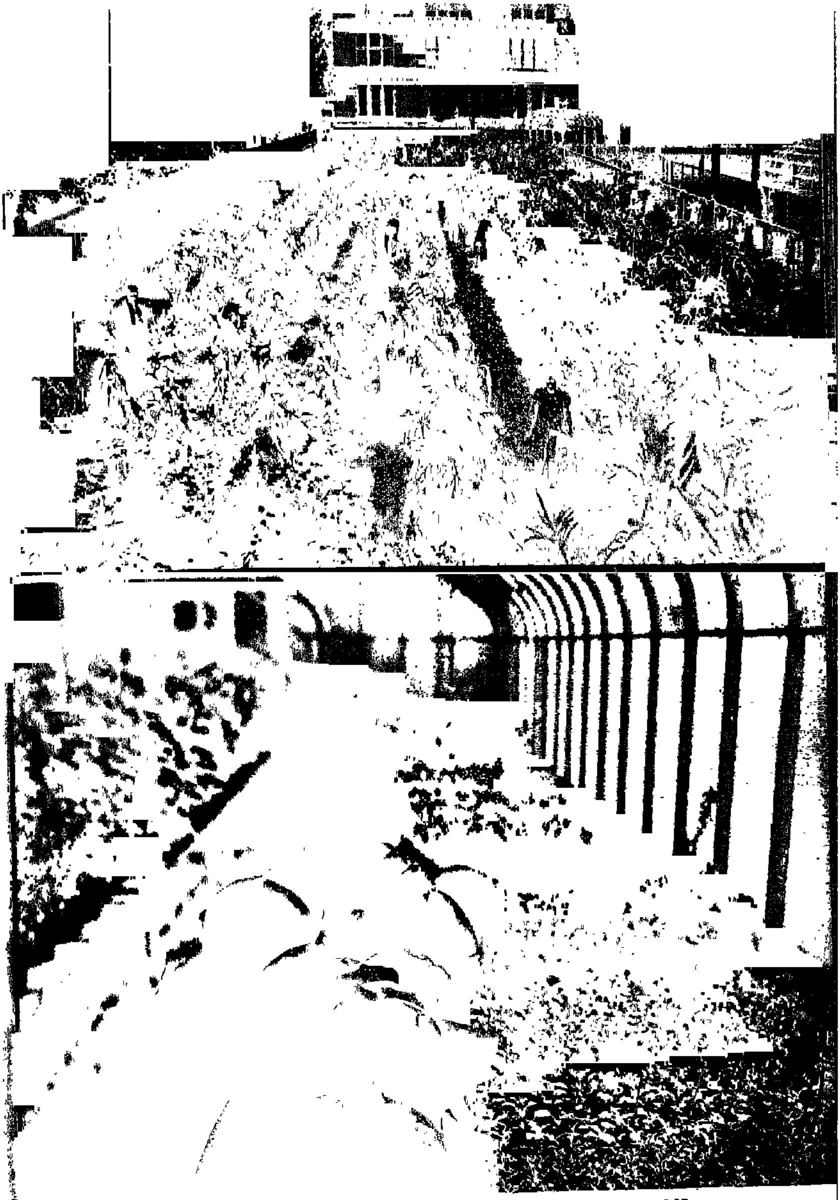
*Get outline maps of the continents of the world. On each name the principal countries and on the map of each country write the names of the two or three most important grain crops grown in the country. If maps are not available make a blackboard chart of this information. Use the school encyclopedia or the World Almanac to get facts.*

Sugar cane was the "honey-bearing reed" of India of long ago. Alexander the Great and his soldiers are supposed to have been the first Europeans to taste sugar. At the present time the average annual consumption of sugar in the United States is nearly one hundred pounds per person. Other plants, such as beets, furnish sugar as well as the sugar cane, but cane sugar is widely used. Much of the "cane sugar" sold by grocers is really beet sugar. In the picture on the preceding page you see a mature plant of the sugar cane. Its similarity to other grasses is quite evident. Can you find three ways in which sugar cane is like oats, wheat, and corn?

Sugar cane requires a rich soil and a warm climate with abundant rainfall and sunshine. For this reason Java in the East, and Cuba in the West are well adapted to the growing of the grass that yields so much of the sweet juice that is evaporated into sugar.

Sugar cane is a perennial and lives in some regions for many years. In Louisiana and in other regions of the United States the plants may live for three or four years. In this respect sugar cane is quite different from many of the cultivated grasses, which are annuals.

Among our most widely used fruits are the apple, pear, quince, cherry, plum, apricot, peach, and nectarine, and such



GARDENING IS A REQUIRED SUBJECT IS SOME SCHOOLS. GREENHOUSES AND OUTDOOR GARDENS MAY BE TENDED BY STUDENTS.

small-fruits as the strawberry, blackberry, and raspberry. If we examine the blossoms from which these different fruits develop, we find that they are similar. For this and other reasons they have been placed in the same family—the rose family. Many of you have watched the blossoms on these trees and bushes grow into the fruits.

The apple is one of our most important fruit crops. There are many varieties of apples grown from Maine in the northeastern part of the United States to Washington on the Pacific Coast.

The citrus fruits include several kinds of fruits now in common use. Oranges, lemons, grapefruit, limes, and tangerines are citrus fruits that belong to a plant family which originated in Asia.

Garden flowers are grown for their color and beauty of form. As with other plants the garden flowers that are alike in structure are grouped in the same family. Many beautiful flowers as well as valuable fruits belong to the rose family. The many varieties of roses are among our most prized flowers.

One of the large industries in this and other countries is the growing of flowers for the florists' trade. *If possible, visit a nursery or a florist's shop and note the different kinds of flowers found there. Then go home and read some reference book which will enable you to classify the different plants under the various family names. A seed catalogue may help you to identify some of the flowers.*

Honey is one of the most easily digested of the several kinds of sugars. Many plants furnish the nectar that the bees change into honey. Clovers, buckwheat, basswood, fruit trees, and small fruits are valuable honey plants in the eastern and northern states. In the Middle West the clovers, alfalfa, Spanish needle, and apple blossoms are sources of fine honey.

In the Far West sage, wild buckwheat, and orange-blossom honey are favorites. Honey may be thought of as a by-product of the various plants from which the bees secure nectar and manufacture it into honey.

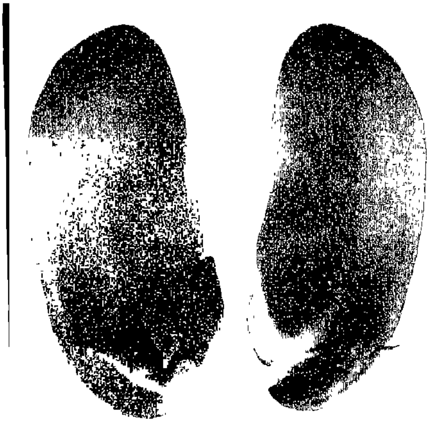
The common garden vegetables include plants that are grown for their fleshy roots, for succulent (juicy) leaves, for edible stems, for their fruits, for seeds, or in the case of the cauliflower for an edible flower.

Plants store food manufactured during favorable growing seasons to carry them through unfavorable seasons. Many plants store food materials in fruits or in seeds to serve as food for the young plants of the next generation. We have learned to take advantage of this food storage and take the parts of the plant for our own use. By long selection of desirable plants and by good care, plants with increased food storage have been developed.

Such plants as beets, carrots, turnips, radishes, and rutabagas are grown for fleshy roots in which starches and sugars are stored. A potato, although it grows underground, is really an enlarged stem. The food material in it is largely starch. Lettuce, cabbage, spinach, endive, mustard, and watercress are grown for their leaves. Squash, pumpkins, tomatoes, eggplants, cucumbers, and the melons produce edible fruits. Peas and beans are eaten for their seeds which contain both starch and some protein.

*If you will soak some large beans overnight you will be able to separate the two parts and examine the young plants*

WHAT CONDITIONS ARE NECESSARY FOR THE DEVELOPMENT OF THE EMBRYO IN THE BEAN SEED?



*between. The young plant is called the embryo. You will be able to see it better with a good hand lens. Food is stored in the two halves of the seed which are forms of leaves. If you will sprout bean plants and watch them grow you will see the seed leaves, cotyledons, shrink as the young plant grows. When we eat beans, we use food material stored to feed a young bean plant until it can establish a root system and begin its own food manufacture. Can you find the embryo in a grain of corn? How does the corn seed differ from the bean?*

Most of our domestic animals belong to a few classes of the animal kingdom. Throughout the world the dog has been the most useful of hunting animals. During the centuries that men lived by hunting wild animals, the dog was his chief helper. The dog, wolf, coyote, and fox belong to the same family. The dog has been the only member of this family to be tamed or domesticated as man's friend and helper. At the time of the settlement of America by Europeans, Indians had tame dogs, but no horses, cows, sheep, or hogs.

Cats belong to the family which also includes the lion, leopard, panther, puma, jaguar, bobcat, lynx, and tiger. This group of related animals is often called the cat family. Cats have been domesticated for a long time because of their useful habit of destroying rats, mice, and other pests that destroy food supplies. Since they also destroy songbirds and gamebirds, some people question their usefulness.

Horses, cattle, pigs, sheep, and goats belong to the *Ungulata,* or the hoofed mammals. All of these animals are *herbivorous;* that is, they eat only plant food and are quite different from the *carnivorous* dogs and cats that are meat-eating animals. The hoofed mammals include most of the domestic or farm animals and are valuable for several reasons: (1) They supply food. (2) They provide clothing materials. (3) They furnish power for farm work. (4) They help to maintain the soil's fertility. (5) They use the foodstuffs grown on farms and that cannot be sold by the farmer.

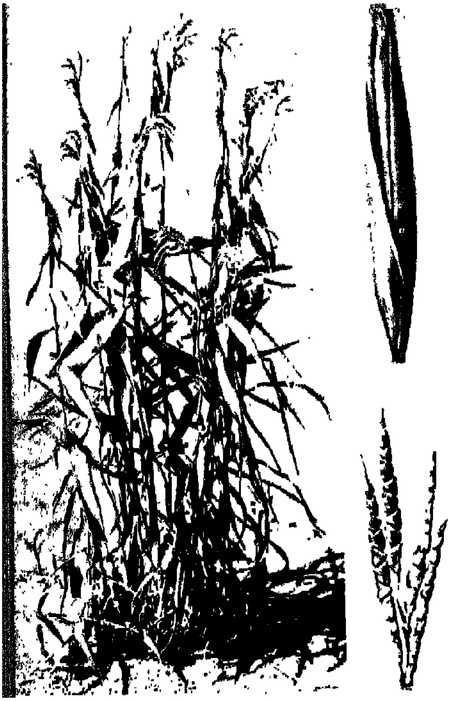
Since the dawn of modern agriculture the hoofed mammals, such as the horse, mule, ox, and water buffalo, have been used for their strength in pulling heavy loads. The last named, the water buffalo, has been used chiefly in the rice fields of the Orient. Oxen are still used as draft animals in some parts of Canada, but horses and mules have replaced them in most parts of this country. The fact that the power of machines is expressed in units of horsepower is proof of the widespread use of horses as draft animals.

Cattle are the most valuable and useful of the different kinds of domestic animals raised on present-day farms. Their flesh is widely used as food. Their milk, butter, and cheese provide healthful and economical foods. Their hides make the leather for shoes and a variety of other purposes.

Goats and sheep are hoofed mammals that are also widely used. Goats furnish milk and cheese in some countries, and their hair provides the fibers that are woven into the fabric called mohair. Sheep are grown for food, and especially for their fleeces, which are the source of our warm, woolen clothing.

Domesticated birds (poultry), which include chickens, geese, ducks, and turkeys, belong to several different families. They were domesticated because they provide valuable food in the form of meat and eggs.

*On the outline maps of the continents find the principal countries. On the map of each country write the names of the most important domestic animals of the country. If maps are not to be had, make a blackboard chart to show this information. Find the countries on the large scale classroom maps. Use the school encyclopedia and a recent World Almanac for getting information.*



TEOSINTE, A WILD GRASS OF MEXICO, IS BELIEVED TO BE THE EARLY ANCESTOR OF CORN.

Plants and animals take on an added interest for us when we realize that every species has developed from some wild and untamed ancestor. Many of our cultivated plants and domesticated animals bear slight resemblance to their early ancestors because growers and breeders have changed them in various ways.

### 3. How have plants and animals been changed under domestication?

You can get an idea of how much plants and animals have become changed after many generations of domestication if you compare some of our familiar garden plants and farm animals with wild forms or earlier forms of the same species.

Most of our commoner domestic plants and animals have been introduced into this country from Europe or Asia. A typical American plant is the familiar field corn. It is thought that our cultivated corn had an ancestor similar to the plant called *teosinte*, found growing wild in Mexico and Central America. Teosinte has grain which grows in a panicle, or head like the sorghums. See illustration. Each grain has its own husk. Compare a well-grown ear of field corn with the picture of the grain of this primitive corn-like plant.

Much work has been done with the improvement of corn to better adapt it to human uses. Field corn has been bred to increase the size of the ear. At the University of Illinois a kind of corn has been developed with a much higher percentage of oil in the grain than ordinary corn. This corn is much used to produce corn oil for many cooking purposes. Most of our varieties of common field corn require a long growing season and so do not do well in the northern United States and Canada. A special variety of field corn has been developed that matures quickly and can be grown farther north. This is sometimes called ninety-day corn because of its rapid maturing.

The garden rose also illustrates the changes that have taken place under domestication. The common sorts of wild roses are usually small and single flowered. Most of them bloom in the spring and then rest until the next season. The colors of those native to our country are usually in shades of pink or white.

The ancestors of many of our garden roses came from Asia or Europe, although some American stock has been used. Compare the colors of the roses grown in gardens and

THE HORSE CALLED EOHIPPUS HAS LITTLE RESEMBLANCE TO THE MODERN HORSE.

by the florists with the wild roses that you know. The hybrid tea roses bloom from time to time during the summer and on into the fall. Most cultivated roses have double flowers.

*If you will get a catalogue from a well-known rose grower you will be able to examine beautiful illustrations of what has been done in changing roses to meet the wishes of flower lovers. You should be able to make an interesting bulletin-board exhibit of illustrations from such catalogues.*

*If you can find a native, wild crab apple bring it to school along with some one of the fine, cultivated varieties of apple such as the Jonathan, the Delicious, Golden Delicious, or Grimes Golden. Can you make a sketch of the wild crab tree and a cultivated apple tree to show differences in appearance? The cultivated apple has not been developed from our native wild crabs but from crab-like apples found in Europe*

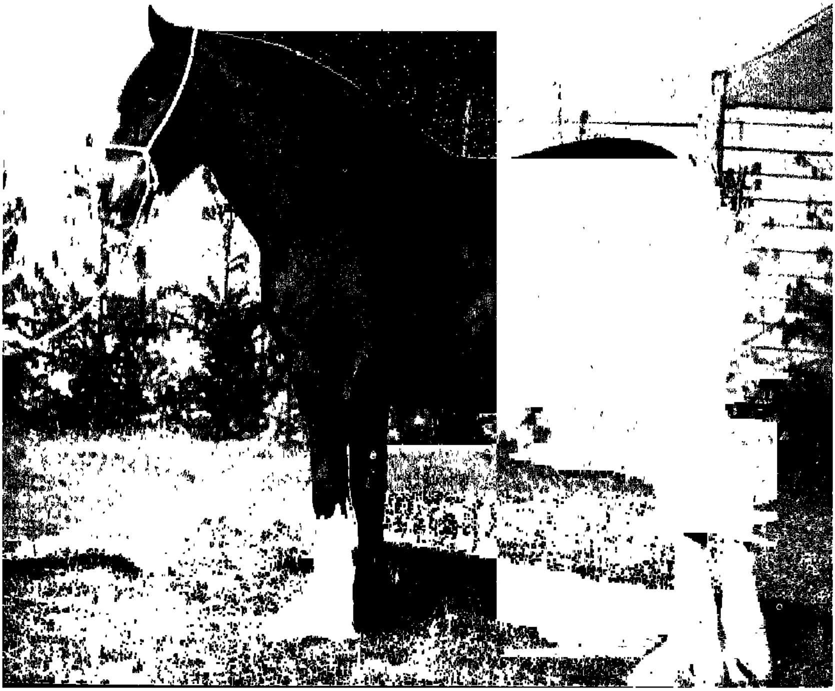
THE THOROUGHBRED HAS BEEN BRED FOR RACING.

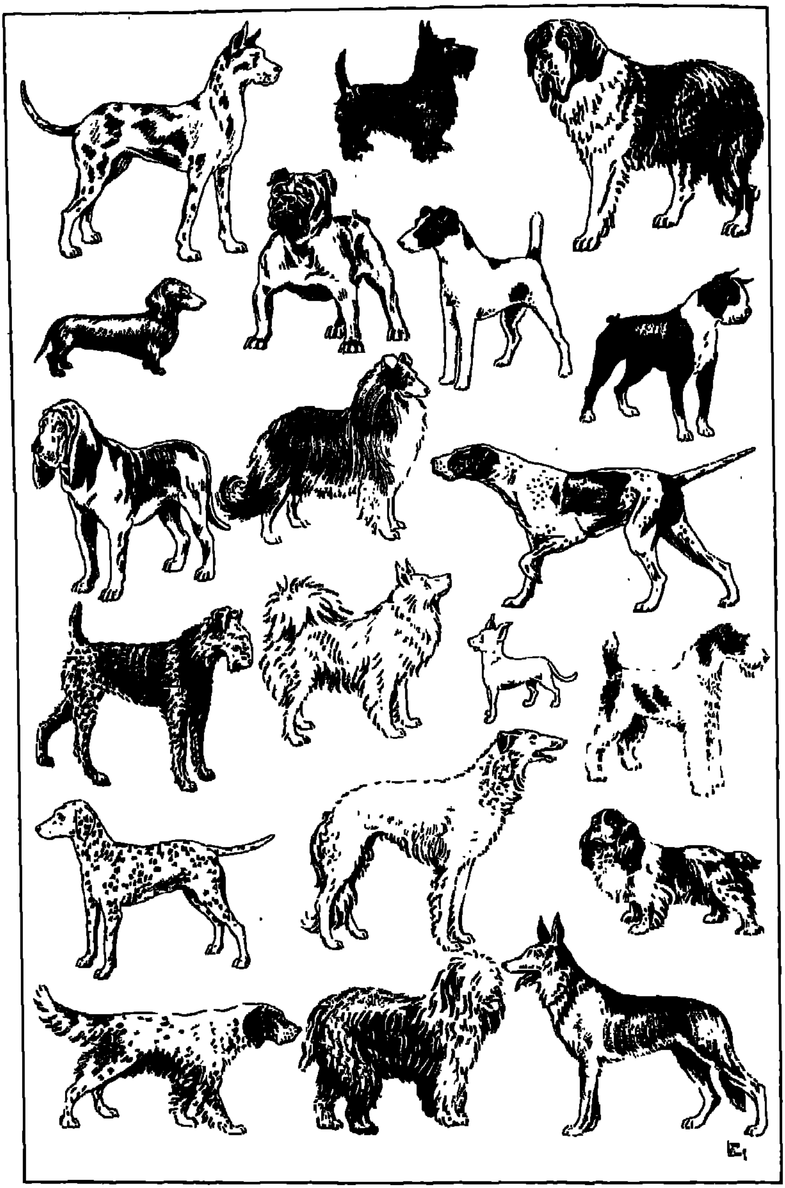
*and Asia. Can you get a sample of a European crab apple? Does the European crab apple differ at all from the American?*

Horses and dogs make interesting comparisons. The ancestor of the horse was a five-toed animal, not much larger than a dog. It is called the *Eohippus.* After generations the horse grew into something like our present horses.

The nearest living relative to the ancestor of domesticated horses is thought to be the small heavy-set shaggy pony found in the cold plains regions of Asia. A herd of these horses has been brought to this country and is kept in the Bronx Zoo in New York. The ancestors of the wild horses found in the western part of the United States were escaped domestic horses. The first of these were probably brought in by Spanish explorers. As we have said, the American Indians had no horses until after the coming of Europeans.

THE CLYDESDALE HORSE IS BRED AS A DRAFT ANIMAL.





HOW MANY DIFFERENT BREEDS OF DOGS CAN YOU RECOGNIZE?

Many breeds of horses have been developed for different human purposes. You can understand this by comparing Shetland ponies, thoroughbred race horses, and such draft animals as the Percheron and Clydesdale. The thoroughbred has been developed for racing. The original stock came from horses brought to Europe from Arabia and mixed with European horses. Present-day draft breeds were largely developed in Europe. These came from stock developed for war and used to carry fighting men in heavy armor. *Find and compare pictures of horses carrying Crusaders in heavy armor with pictures of some of our present draft breeds.*

Domestic dogs illustrate the wide differences that can be produced in domestic animals of the same species. As far as we know there are no living ancestors of domestic dogs. The wild dingo of Australia is much like the tame dog. In our country, wolves and coyotes are near relatives. Dogs are raised for hunting, for herding stock, as watchdogs, for police work, and simply as pets. They vary in size from such dogs as the toy poodle to the Great Dane and the Saint Bernard. Compare the shape of the wolfhound and greyhound with that of the spaniel and the dachshund.

You should be able to make a collection of pictures of dogs of different breeds from the advertising pages of magazines. House and garden and sportsmen's magazines usually carry advertising pictures of dogs. *Make a bulletin board exhibit of the collection. Arrange and label the pictures to show the wide range of differences that have been produced in dogs. Add a picture of a wolf to show the contrast.*

Changes produced in plants and animals to make them better fit our own purposes as human beings are not always an advantage to the plant or animal. For example, a cultivated apple tree does not compete with grass, weeds, and underbrush as well as a wild crab. The wild crab has thorns which keep browsing animals from eating its branches and bark. The cultivated tree has no such natural protection.

How well would some of our breeds of dogs get along under wild conditions with no protection, no one to feed them, and no shelter? Can you think of a cocker spaniel, or a Scottie taking care of himself alone in a forest or out on the plains with the coyotes?

### 4. How are changes in domesticated plants and animals produced?

We can explain a part of the differences between wild and domesticated plants and animals by the care received by the domesticated ones. In the wild, a plant must compete with many crowding neighbors for water and mineral foods, sometimes even for sunshine and air. A well-cultivated plant is grown in a favored place and much of the competition of other plants removed by thinning and the cutting away of weeds. In many cases the cultivated plant is watered in dry times. This makes it possible for the cultivated plant to grow to the limit that it is capable of reaching. Sometimes you can see this effect under natural conditions when you find a particular plant that has happened to grow by itself under particularly favorable circumstances.

*If you can have the opportunity, you may like to try to see how fine a plant of some wild kind you can grow. Be sure to provide the conditions to which such plants have become adapted. Cultivate, fertilize, and water your plant. Can you make it grow better than average wild plants? One of the small, wild prairie roses, or a native cactus, will make a good subject.*

Some kinds of animals also respond to good care. If an animal is well fed, protected from severe weather and climatic conditions, and protected from its natural enemies, it

THE ROCKY MOUNTAIN SHEEP HAVE FLEECE WHICH RESEMBLES THAT ON SOME OF THE DOMESTIC WOOL BREEDS.

should grow into a fine specimen of its kind. Some animals do not seem to thrive when kept penned or caged. These animals seem not to respond to the treatment that we are accustomed to give domestic animals.

In many cases good care will produce very fine individual specimens of plants or of animals. However, something else is needed to produce as great changes as can be found between some breeds of horses or of dogs.

One process nearly always used in attempting to get plants and animals more nearly to fit our needs is that of *selection.* Sometimes this is called *artificial selection* as compared to the *natural selection* which goes on all of the time under natural conditions. See page 135.

By selection in plant and animal breeding we mean simply that we select those plants or animals that most nearly represent what we wish, and use these selected individuals as parents of the next generation.

If you were to go to a basket of apples to get one to eat you would probably pick up the apple that most appealed to you. This might be the largest, or the one of the most attractive color. Now if you proposed to grow apple trees from seed you would select what seemed to you to be the most attractive apple that you could find from which to get seed.

If we wish large potatoes we select large potatoes from the bin to use as seed potatoes. If we want to grow large ears of corn, we select seed from large ears, or better, go to the field and select a large ear from a large and thrifty plant. If we wish to raise race horses, we select relatively lightweight running horses as parents. If we wish horses to draw heavy loads, we look for large muscled heavy horses to serve as parents. If we want hens that will lay many eggs in one year, we take eggs for hatching from hens that have high egg laying parents and from a cock whose mother also has a high record for egg laying.

THE LARGE, WHITE, STRONG-STEMMED SHASTA DAISIES ARE THE RESULT OF CROSSING DAISIES FROM THREE CONTINENTS.

Luther Burbank was one of the famous plant breeders of the United States. His method of work depended very largely upon selecting plants from large numbers grown from seeds of the same parent. *Find* *the story of one of Burbank's successful experiments and report it to the class. You may be interested in the Shasta Daisy, the Burbank Potato, or the Thornless Cactus.*

In trying to improve living things to suit our own purposes we always have to deal with two natural laws. One of these we call *heredity*. The other we speak of as *variation.*

By heredity we mean that offspring resemble their parents. Sometimes the resemblance is to a grandparent or some other ancestor. We expect puppies to look like dogs and not like cats. Purebred cocker spaniels will look like spaniels and not like foxhounds. It is heredity that enables us to produce breeds of animals and varieties of plants all resembling one another.

By variation we mean that plants or animals of the same

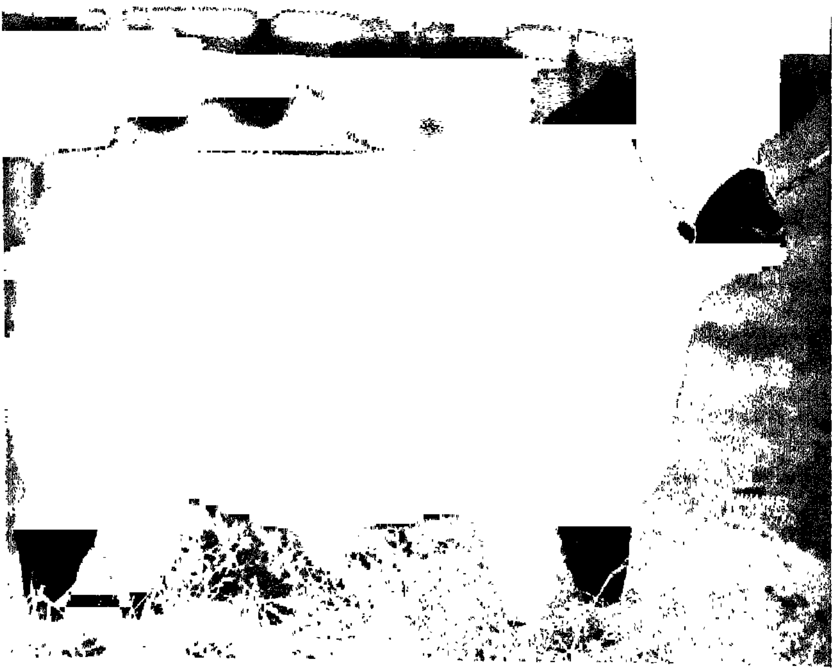
THIS IS AN EXPERIMENTAL WHEAT FIELD AT THE NORTH DAKOTA EXPERIMENT STATION. MANY NEW VARIETIES OF PLANTS HAVE BEEN DEVELOPED AT THE VARIOUS STATE EXPERIMENT STATIONS.

JERSEY COWS ARE GOOD MILK-PRODUCING ANIMALS.

species, breed, or variety, differ from one another. No two animals of a kind are just exactly alike. Two plants from the same parents are different in some ways from one another. There are always small differences in living things coming from the same parents.

It is this fact of variation that has been used in developing "new" or "improved" plants. Plants are selected which have variations most like the kind of plant that the grower wants. These are used as parents of the next generation.

A recent story will illustrate what can be done with plants by selection. The marigold is an easily grown attractive annual flower. The plant has a distinct odor that is disagreeable to many people. Flower growers have been trying to get plants without this odor. Obviously it would be common sense to grow marigolds from seed coming from plants with as little odor as could be found. Thousands of seedlings were



BEEF CATTLE AND DAIRY CATTLE ARE RAISED FOR ENTIRELY DIFFERENT PURPOSES.

grown and many workers employed to search among them for a plant without odor. At last such a plant was found. Seeds from this plant have been planted and new generations grown until now there is a strain of odorless marigold plants. Can you find a description of the odorless marigold in one of the new seed catalogues?

The common beet has considerable sugar. Plant breeders sampled the sugar content of beets and grew seed from those with the highest amounts of sugar until a strain of beets with a very much higher percentage of sugar was established. This process of selection has increased enormously the yields from fields of beets used as a source of commercial sugar.

Most plants grown from seed have two parents. All of our higher animals have two parents. The children inherit characteristics from the families of both parents. You can see that with every new mating the possibility of varied inheritance is increased. This speeds up at a rapid rate the production of differences in the inherited characteristics.

To keep animals of one breed nearly alike, only parents of the same breed are mated. Offspring of ancestors of the same breed for many generations are said to be pure bred.

Some plants have such a mixed ancestry that it is difficult to predict what the offspring will be. This is true for garden potatoes, cultivated roses, and most of our common domesticated fruits. Some plants can be grown from pieces of a parent plant. When this is done the new plants are like the one from which the pieces are taken. If seeds were planted, the new plants might be like either parent or like any one of a great number of ancestors.

To keep plants alike many of our domesticated ones are grown from parts of old plants. Sometimes cuttings, pieces of plant stems, are used. These are planted in sand, water, or soil until the pieces have formed roots. Sometimes buds are taken from twigs of the parent plant and set under the bark of a rootstock of some other variety that has been grown from seed. Sometimes pieces of one plant are grafted on a plant of another variety.

Potatoes are commonly grown from pieces of old potatoes. If the piece planted has a bud, or an "eye," it will usually grow a new plant. Geraniums and some roses can be grown from cuttings. Most commercial fruit trees and roses have been budded or grafted.

You can try growing some plants from cuttings. *Fill a flat box with clean sand. Take cuttings of matured stems of geranium, coleus, or wandering Jew. Place these cuttings in the sand after it has been well watered. Keep the sand moist, but not too wet. In a few weeks these cuttings should have started roots and be ready to be potted in soil. Often pieces of coleus, or ivy can be started in a jar of water.*

Can you explain how it has been possible to grow seedless oranges? How can seedless watermelons be grown? Are such melons practical?

If two plants of the same species but of different varieties are mated the offspring are called *hybrids*. This process of forming hybrids further mixes the ancestry of the offspring so that greater variation is expected. When these variations have been obtained the new varieties are produced by the processes of selection which we have described. Hybrid plants often do not resemble parents when grown from seed, so that it is necessary to grow the new plants from cuttings, buds, or grafts.

Many of our cultivated plums are hybrids. So are great numbers of cultivated grapes.

There are a few animal hybrids. Among animals, a hybrid is produced by mating parents of related species. The offspring of parents of different breeds are not called hybrids among animals. For example, a dog with ancestors of different breeds is known as a mongrel and not a hybrid.

The most familiar animal hybrid is the mule. The mother of a mule is a mare and the father an ass or donkey. Mules do not have offspring and further variation is stopped by this fact. Other animal hybrids have been formed between the zebra and the horse, the buffalo and common cattle, the lion and the tiger, and the turkey and the hen.

### 5. Why do we need to conserve our plant and animal life?

For years people have been giving attention to the development of new types of domestic plants and animals, and have failed in many instances to conserve our native plant and animal life. There are many examples of the disastrous results that follow the needless destruction of native plants and animals.

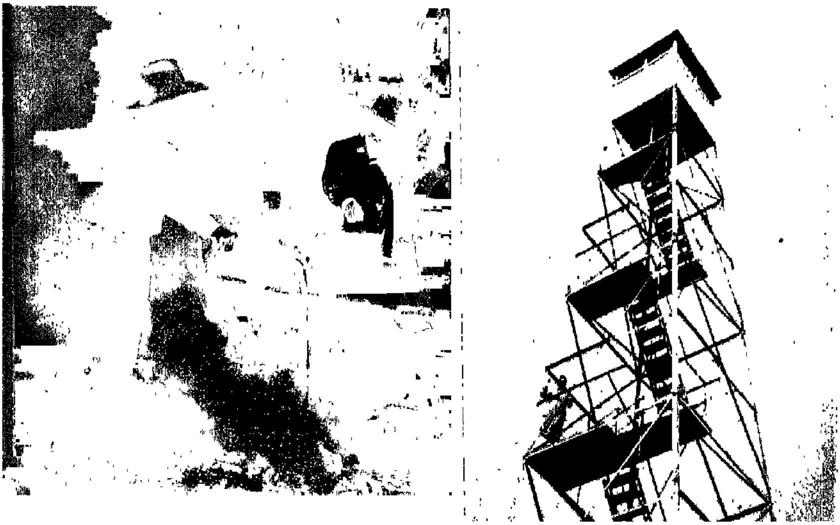
THIS IS A U. S. FOREST SERVICE SEAL.

Many of you have entered a wooded area and have seen signs bearing the seal of the Forest Service of the United States Department of Agriculture that read: CAMP FIRES PROHIBITED HERE or SHOOTING PROHIBITED. These regulations, which are strictly enforced, were not made to lessen our pleasure and enjoyment while in the forests, but to protect the plants and animals of these regions so that people may always benefit from them.

Visitors to many of the National forests will see cattle and sheep grazing in the lowlands during the summer months. The owners of the livestock pay a small fee for each animal that fattens on the wild grasses of the mountain meadows. When forest fires occur the grazing grounds of many wild and domestic animals are destroyed.

Water is one of the few things that are essential or necessary for any kind of life. The water derived from the wooded hills and valleys has greater value than all of the lumber cut from our forests. Growing trees help to hold water and pre-

YOU CAN HELP PROTECT THE FORESTS. OF WHAT USE IS A WATCH TOWER?

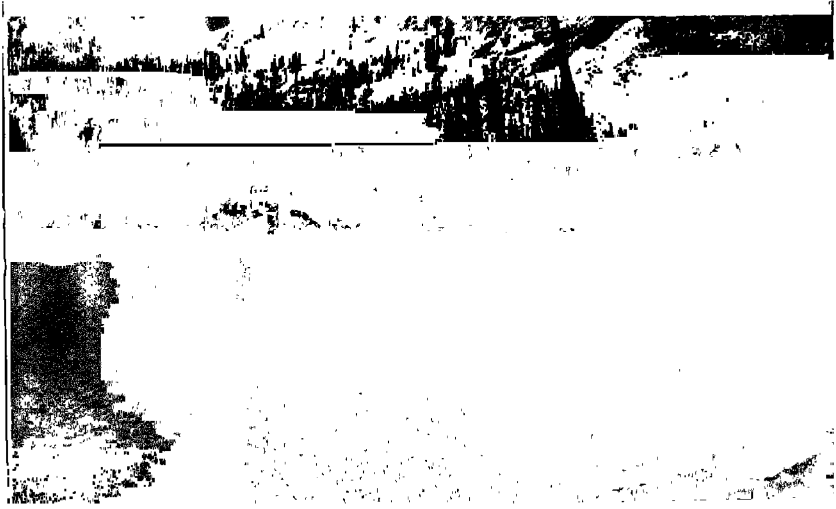


vent the washing away of soil. In forested regions, the falling leaves and pine needles change the topsoil so that it holds much more moisture. The roots of the trees help to bind the soil. If the trees are cut away, the rain that falls runs off too quickly causing floods in the lower valleys. The porous top soils are washed away and much water is wasted that could be used.

Forests are very necessary to help conserve our water supply and prevent floods in times of heavy rainfall. For their water supply many large cities, such as New York City, Los Angeles, and San Francisco, depend upon the rains and snows that fall on the distant mountains. Much of the agricultural West is irrigated by water that fell on forested slopes and was later piped from rivers or artificial lakes called reservoirs.

Fire is a great enemy of the forests. The majority of forest fires are caused by carelessness. Visitors to forest regions can help to prevent serious fires by heeding the suggestions in the poster on the opposite page. We can sum up the unhappy results of forest fires by comparing the benefits that come from green forests as contrasted with the desolation caused by forest fires.

A MOUNTAIN LAKE IS OFTEN A GOOD SOURCE OF PURE DRINKING WATER.



| GREEN FORESTS | FOREST FIRES |
|---|---|
| Yield abundant timber supply | Devastate productive tree growth |
| Decrease lumber prices | Increase cost of wood products |
| Insure houses for all | Curtail home building |
| Support industries | Hinder industrial development |
| Build up communities | Pay no wages or taxes |
| Make waste land productive | Create idle acres |
| Protect wild life | Kill birds, fish, and game |
| Provide outdoor playgrounds | Make desolate the beauty spots |
| Promote a water supply | Destroy a source of water supply |
| Create national wealth | Destroy natural resources |

Does your state have any state and national forest preserves? *Get a large scale map of the state and color these in on it. Post on the bulletin board.* Many of the maps from state highway departments show the locations of parks and forest preserves within the states.

Both the prairie region of considerable rainfall in the central part of the United States and the great plains region of less rainfall between the Missouri River and the Rocky Mountains show the lack of conservation as well as do the forest regions. The prairies of the Mississippi Valley region were at one time covered with prairie grasses, legumes, and other soil-binding plants. When the prairies were plowed and repeatedly planted in crops grown in rows, like common field corn, much of the upper soil was washed into near-by streams. In some fields repeated planting of corn exhausted the minerals needed by growing crops.

Great herds of buffalo once roamed over the drier great plains region east of the Rocky Mountains. After the buffalo were almost completely destroyed these plains were used for grazing cattle. Much of the land was overgrazed. Later farmers came in and plowed much of the land, destroying the native buffalo grass that had served as a soil binder. In recent years periods of drought have occurred and in some regions the soil, deprived of its covering of sod, was blown long distances. The people who live in the so-called "dust bowl" of the Southwest or in the Dakotas will not soon forget the dust storms of a few years ago when tons of fertile topsoil were blown away. When rains did come, the land was badly washed by erosion. It is almost impossible to estimate the financial loss to the farmers occasioned by the loss of their fertile topsoil. Now the people in many farming sections are trying to repair the damage in a small measure by planting soil-binding grasses or other crops that keep the soil covered to serve the same purpose as the original grasses.

The buffalo which fed on the native grasses were of great importance to the Plains Indians. From these animals the Indians obtained food, clothing materials, skins for their tepees and canoes, and bones that they fashioned into weapons.

The Indians killed for necessity in order to provide themselves with food and clothing. In this respect they were more civilized than the white men. Until 1869 buffalo were very plentiful in the prairie states. In that year the Union Pacific Railroad was completed across the plains and hunters swarmed into the new territory. Within a few years the herds of these large mammals were destroyed, and today just a few thousand individuals remain within the safe boundaries of some of the National Parks.

The fate of the passenger pigeon warns us of what may happen to other bird species unless care is taken to prevent their extermination. The passenger pigeons were once common birds in a large section of the United States. They flew in such large numbers that they actually darkened the sky. Today there is not a single living representative of these birds. There are other species of game birds that will probably be preserved because people have awakened to the necessity of protecting them through the enforcement of laws that were designed to protect them.

The ruffed grouse and the sharp-tailed grouse are related to the race of heath hens, the last survivor of which died in 1932 at Martha's Vineyard. The prairie chicken, or pinnated grouse, makes its nest in the tall grasses of the prairie. Therefore many of these birds were driven from their homes when the prairie grasses were destroyed. The bird is now found as a permanent resident in Nebraska, the Dakotas, Minnesota, Michigan, Wisconsin, Illinois, Manitoba, and Saskatchewan. The prairie chicken moved when the balance of nature was disturbed as it was in Iowa and other regions by the removal of the tall grasses in which it nests.

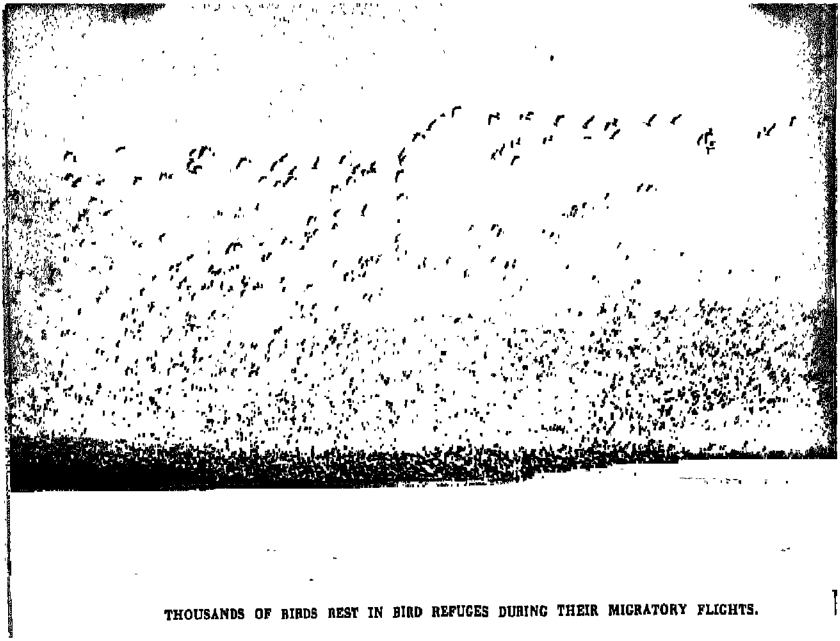
PRAIRIE CHICKENS ARE GAME BIRDS THAT ARE FAST DISAPPEARING.

Many kinds of waterfowl, such as wild swans, ducks, and geese, were once much more abundant than they are now. These birds furnished a large part of the food supply of the Indians and the pioneers during certain seasons of the year. They are still seen in large numbers along our inland lakes and rivers, and it is hoped that game laws will prevent their complete extermination. The laws usually limit the shooting of these fowl to a certain season of the year.

The native fishes are another natural resource that requires consideration. Bass, sunfish, catfish, perch, trout, and salmon provided a dependable food supply for both the Indian and the pioneer. More recently, these animals have been taken in such large numbers from our inland waters that the supply has been greatly lessened. Food fishes supply a valuable source of protein food as well as great pleasure to fishermen, so we cannot afford to allow the supply to be in any danger of extermination from lack of necessary protection.

Recreation is one of the necessities of modern life. Outdoor recreation provides the most healthful and to many people the most satisfying form of relaxation. The native plants and animals make the out-of-doors inviting and interesting. With the coming of a shorter working day and a shorter working week, people will have more time for recreation and the study and enjoyment of plant and animal life. Parks are a necessity for these people. City parks provide some of the people in large communities with their only opportunity to enjoy shady lawns, singing birds, and flowering plants. State Parks and National Parks provide camping grounds and opportunities to enjoy a longer, inexpensive vacation. As you visit the different city, state, and national parks you will find that they are interesting, because they are the homes of a variety of plants and animals which are protected from the greed of collectors and the selfishness of hunters.

*Make a collection for the classroom bulletin board of pictures of native animals that are very much in need of protection. In one corner include pictures of our native animals that are now extinct.*



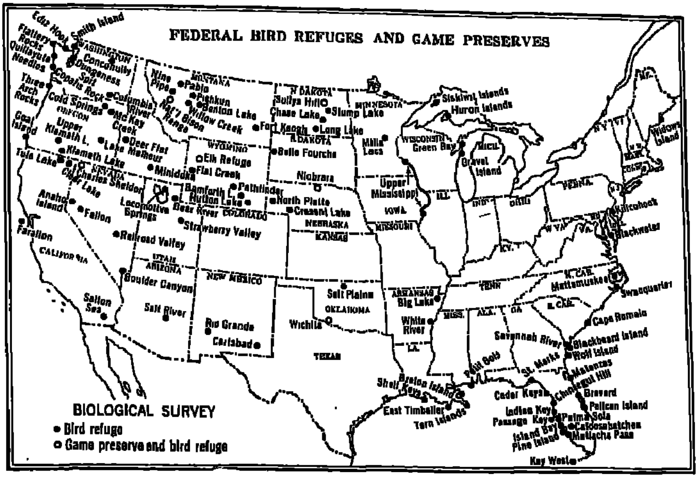
THOUSANDS OF BIRDS REST IN BIRD REFUGES DURING THEIR MIGRATORY FLIGHTS.

### 6. What is being done to prevent the extermination of wild life?

If we visit the same woods, mountains, or seacoast for a few successive years, we see the effects of man's activities on the wild life of the region. New and improved highways bring regions that were once inaccessible to all who drive automobiles. Plant life, especially shrubs, wild flowers, and ferns, shows the effects of the visitors. Animal life is constantly on the move, and so we do not realize the harm that hunters, campers, and others cause to the wild animals and birds until a species becomes entirely or nearly extinct. If a few specimens remain these are placed in zoos and carefully guarded.

There are various organizations that try to protect native birds, larger animals, and plant life, so that people may always enjoy them and profit by their presence.

Birds used to be slaughtered in great numbers during their



THE BIRDS ARE SO IMPORTANT TO AMERICAN FARMERS THAT THE UNITED STATES BUREAU OF BIOLOGICAL SURVEY HAS A NUMBER OF BIRD REFUGES.

migratory flights. A treaty was signed in 1918 by representatives of the governments of the United States and Canada. This Migratory Bird Treaty Act made it unlawful to capture, kill, or transport any migratory bird, or any part, nest, or egg of such bird, except during the open season established by the Secretary of Agriculture. Open seasons are provided for ducks, geese, swans, rails, sandpipers, and others. Orioles, swallows, thrushes, wrens, and woodpeckers are protected throughout the year and can never be taken. Robins and bluebirds cannot be killed within the United States.

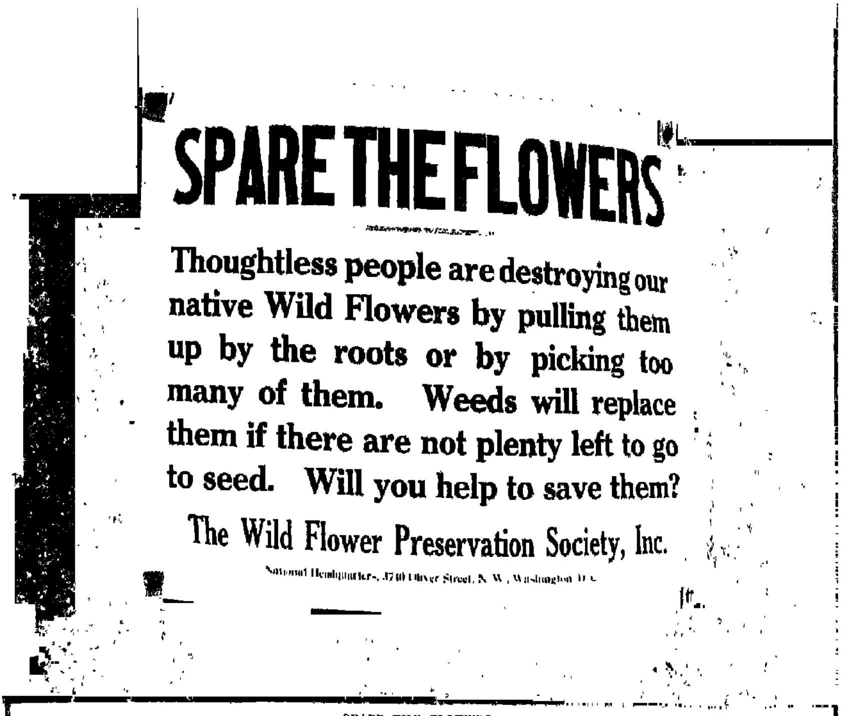
The Bureau of Biological Survey has over one hundred wild life refuges. Some of these refuges are for migratory birds. Land is purchased which is suitable as feeding, resting, and breeding grounds for the various species, some of which are migratory waterfowl. One of the most distant of these refuges is the Aleutian Islands Bird Refuge in Alaska. Gulls, ducks, geese, auklets, and murres are some of the bird species

THE BOBWHITE IS A GAME BIRD OF GREAT ASSISTANCE IN DESTROYING WEED SEEDS AND INSECTS.

which are protected in this refuge. Other bird refuges that are maintained by the Bureau of Biological Survey are shown on the map on page 387.

Many schools have an Audubon Society. The National Association of Audubon Societies was founded in 1902 and since then its work of bird protection has spread to all parts of the United States. The Audubon Societies own and maintain several sanctuaries for the protection of the birds. The Paul J. Rainey Wild Life Sanctuary, which is in Vermilion Parish, Louisiana, extends over forty square miles of marshland. Twenty-one species of ducks and blue and lesser snow geese are some of the birds that find protection there during the winter months. Other sanctuaries owned by the Audubon Societies are found in Florida, Georgia, Maine, North Carolina, New Jersey, New York, South Carolina, Texas, and Virginia.

Many of the states have used their powers to pass laws to protect the birds. For example, the bobwhite or quail became so scarce in Iowa a few years ago that people feared the birds would become entirely extinct. In order that this species should not die out, a law was enforced for five years which prohibited the shooting of quail. At the end of this five-year period the birds had so increased in numbers that there could again be an open season on quail each year.



SPARE THE FLOWERS

Thoughtless people are destroying our native Wild Flowers by pulling them up by the roots or by picking too many of them. Weeds will replace them if there are not plenty left to go to seed. Will you help to save them?

The Wild Flower Preservation Society, Inc.

National Headquarters, 3740 Oliver Street, N. W., Washington D. C.

SPARE THE FLOWERS.

Counties, towns, and cities can pass ordinances which prohibit the killing of certain bird species within the limits of the county or city. Such laws when properly enforced are of great value in preventing the destruction of helpful birds.

The Wild Flower Preservation Society of America has interested members in various parts of the United States. These people study wild flowers and their natural uses, and try to teach others to SPARE THE FLOWERS. You may have seen one of these posters. See the photograph above. This society gives six rules for the protection of our rare native plants, which are disappearing from our fields and woods.

1. Pick them very sparingly, especially if near a large town or tourist point.

2. Do not buy rare wild flowers from street venders or florists.

3. Do not pull them up by the roots; leave plenty to go to seed in order that all may enjoy them the following year.

4. Pick other flowers in moderation unless abundant or weedy.

5. Do not break, or tear off woody flowering branches. Cut them close to the base, so that the wound may heal over and prevent fungus diseases from entering.

6. Do not drop lighted matches, cigars, or cigarettes in the woods or fields. Do not burn fields intentionally, as the burning destroys humus in the soil necessary for the growth of desirable plants, and causes them to be replaced by troublesome weeds.

On any holiday or Sunday in the spring, discarded bouquets of bloodroot, spring beauty, dogtooth violets, Dutchman's breeches, larkspur, lady's-slippers, columbine, violets, and hepatica are likely to be found along country roads near towns and cities. The flowering dogwood, found in a variety of localities, is said to be destroyed more selfishly than any other plant.

Different wild flowers need protection in different states. The American pasqueflower in South Dakota, the blue columbine in Colorado, the trailing arbutus in Massachusetts, and the lady's-slipper in Minnesota are in need of protection.

*Secure pictures of different plants that are in need of protection and display them on the class bulletin board.*

The Save-the-Redwoods League has been of great service to present and future America. The redwoods grow in no other place in the world except California. Many acres of these beautiful trees were cut for lumber before the league was organized.

Plant life as well as animal life is protected in all of the state and national parks. In order to protect the birds and other animals, guns and dogs are not allowed to be brought into any of them.

1. Plant and care for a garden which contains at least six varieties of vegetables. This may be a class project.
2. Plant and care for a flower garden which contains six or more varieties that are annuals.
3. Secure some wild flower seeds and develop a wild flower garden in your own yard. Your State Conservation Commission can tell you where to obtain seeds.
4. Make a collection of cultivated grasses to show how the seeds are borne on the stems.
5. Prepare a class report on the redwoods and the lumber industry.
6. Make a collection of seeds to show the different ways in which seeds are scattered.
7. Prepare a report for the class on the wild animals which are found in the different national parks, as for example, Glacier National Park.
8. Care for three different kinds of potted plants.
9. Grow two kinds of flowering plants from seeds in pots.
10. Some members of the class may want to form a branch of the Wild Flower Preservation Society of America. You can obtain information by writing to 3740 Oliver Street, Washington, D. C.
11. Other members of the group may want to form an Audubon Society. Information may be obtained by writing to National Association of Audubon Societies, 1775 Broadway, New York City.
12. Write to The American Tree Association, 1214 Sixteenth St., Washington, D. C., for copies of *The Forestry Primer*.
13. Prepare an exhibit of pictures of the different breeds of dogs and display them on the class bulletin board.
14. Prepare a class report on the cultivation of sugar cane.

15. Prepare a special report on the history of the orange in the United States; also on the history of the grapefruit.

## SOME THINGS TO REMEMBER

1. A useful plant or animal is one that can be made to serve the needs of human beings.
2. Different plants and animals are useful to people in different parts of the world.
3. The adjustment of plants and animals to one another and to the environment in any one place is called the balance of nature.
4. When human beings use any one kind of plants or animals in great numbers, the balance of nature is disturbed.
5. Farming disturbs the balance of nature.
6. Those animals and plants that have long been grown especially for human uses are called domesticated plants and animals.
7. The fact that offspring resemble parents or other ancestors is called heredity.
8. Variation means that plants or animals of the same species, breed, or variety differ from one another.
9. The most valuable food plants used by people throughout the world are grasses.
10. Corn is the most valuable grain crop grown in the United States.
11. Vegetables are provided by plants that store food in roots, stems, fruits, seeds, or leaves.
12. Most of our domestic animals belong to the order of hoofed mammals.
13. Cattle are the most important of the several kinds of domestic animals.
14. All domesticated plants and animals have been developed from their wild ancestors.
15. The wild plants from which most of the cereals or grains have come are unknown.

16. The ancestor of corn is believed to have been similar to a wild grass called teosinte.
17. All varieties of apples have come from a wild plant which resembles the crab apple.
18. Our breeds of domestic cattle originated in Europe.
19. The early ancestors of the dog are unknown.
20. Our present-day chickens had ancestors that lived in the jungles of India, South China, and the East Indies.
21. The sugar beet was bred for its large amount of sugar.
22. New varieties of plants and animals may develop in the wild by natural selection and the survival of the fittest.
23. The various breeds of domestic animals have been obtained largely by selecting the ancestors for new generations.
24. Different breeds of different kinds of animals have been developed for definite human purposes.
25. Everyone loses when the forests burn.
26. The dust storms that have occurred in the great plains region were due to men's shortsightedness in plowing up the native grasses.
27. Passenger pigeons, now extinct, were once common birds.
28. Parks are needed for recreation areas.
29. Birds are protected in wild-life refuges and in sanctuaries.
30. The Wild Flower Preservation Society has helped to prevent the complete extermination of many wild plants.
31. There are many government agencies which protect plant and animal life.

### BOOKS TO READ

Barbour, Ralph Henry. *The Boys' Book of Dogs.* Dodd, Mead & Company, Inc.

Bruette, William A. *Modern Dogs.* Grosset & Dunlap, Inc.

Ditmars, Raymond L., and Bridges, William. *Wild Animal World.* D. Appleton-Century Company, Inc.

Du Puy, William A. *Our Plant Friends and Foes.* John C. Winston Company.

Du Puy, William A. *The Nation's Forests.* The Macmillan Company.

Du Puy, William A. *Wonders of the Plant World.* D. C. Heath & Company.

Hammond, Carsie, and Woods, Ralph H. *Today's Agriculture.* J. B. Lippincott Company.

Mitchell, Lucy Sprague. *Horses Now and Long Ago.* Harcourt, Brace & Company.

Roberts, Elmer, and Davenport, Eugene. *Plant and Animal Improvement.* Ginn & Company.

Story, Isabelle F. *Glimpses of Our National Parks.* Washington: United States Department of Interior, National Park Service.

Seed Catalogues

### OTHER THINGS TO READ

*Government Publications,* Superintendent of Documents, Washington:

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Wright, G. M., and Thompson, B. H. *Fauna of the National Parks,* Series No. 2.

*Farmers' Bulletins:*

No. 491. *Breeds of Dogs.*
No. 576. *Sheep for the Farm.*
No. 612. *Breeds of Beef Cattle.*
No. 702. *Cottontail Rabbits in Relation to Agriculture.*
No. 952. *Breeds of Light Horses.*
No. 1089. *Reindeer in Alaska.*
No. 1171. *Growing Annual Flowering Plants.*
No. 1242. *Permanent Fruit and Vegetable Gardens.*
No. 1644F. *Local Bird Refuges.*
No. 1759. *Game Management on the Farm.*

# UNIT ELEVEN

# UNIT ELEVEN

# Understanding the Human Machine

## WHAT THIS UNIT IS ABOUT

The human body is a machine with few spare parts. When some vital organ, such as the stomach, heart, lungs, or kidneys, is not doing its work properly, illness and sometimes death result. Much worry and unhappiness, as well as illness, occur because people do not know enough about the human machine to care for it intelligently.

Scientists have conquered many of the plagues that have destroyed so many thousands of people in the past. Smallpox, bubonic plague, yellow fever, and typhoid fever are some diseases that can be controlled. Today the organic diseases, such as heart disease, cause more suffering than the germ diseases.

How much do you know about the machine, your body? What do you know about keeping it in good running order? Many people know more about the construction and operation of their automobiles than they do about the far more complicated mechanism called the human body. It is far more important to keep your own body in good running order than it is to have the family car regularly serviced. After studying this unit, you should be able to care for it more wisely. This knowledge will help you to develop the powers of resistance so necessary for a long and happy life.

# Understanding the Human Machine

## UNIT PROBLEMS

1. Why are our bodies like machines?
2. Why are we able to move?
3. How can we build stronger bones?
4. How does digestion take place in the human body?
5. How are building materials distributed through our bodies?
6. How is oxygen supplied to all of the cells?
7. What defenses has the body against injury and disease?
8. How can wastes be removed from the human machine?
9. What guides and controls the human machine?
10. How can we best care for our own bodily machinery?

### 1. Why are our bodies like machines?

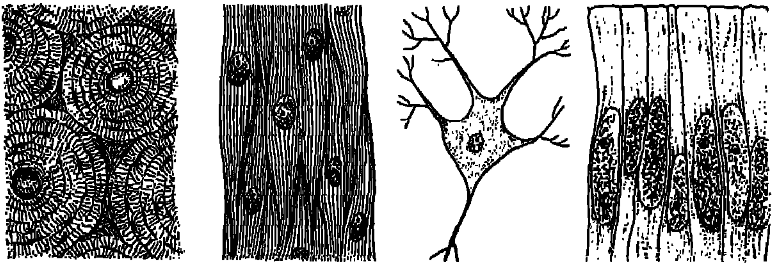
The human machine is sometimes likened to an automobile. The automobile derives power from the "burning" of gasoline. The body derives heat and energy from the food that we eat.

When we look at a shiny new car, we think of it as one large unit. On closer examination we find that it consists of several systems. Boys who have worked in an automobile shop can readily identify the chassis, electric system, cooling system, transmission, and the power plant or engine.

The human machine also consists of several systems. You may have seen a human skeleton which furnished the framework for the organism called a boy or a girl. The bones belong to the *skeletal*, or bony system. Muscles are connected to the bones so the movement of the body is possible. These muscle tissues make up the *muscular* system. The lungs, and the tubes that carry air to them from the nose, are parts of the *respiratory* system. The stomach, mouth, and intestines belong to the *digestive* system. The heart, blood vessels, and the blood belong to the *circulatory* system. The organs that remove wastes from the body, as the kidneys, are classified under the *excretory* system. The entire mechanism is controlled by the *nervous* system, which includes the brain, the spinal cord, and the nerves.

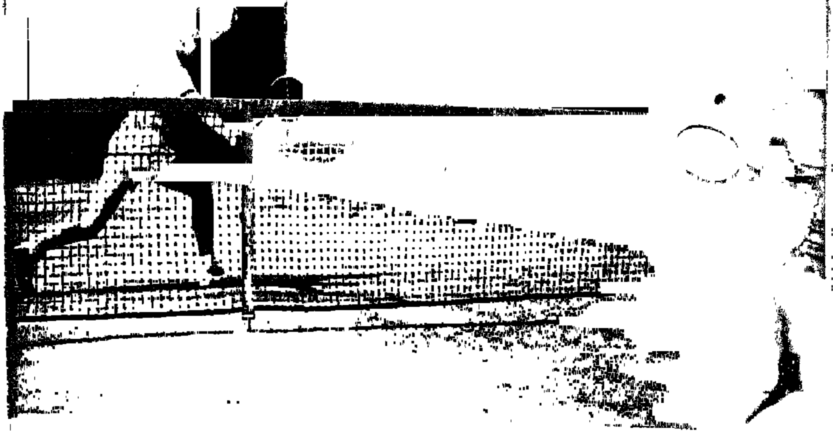
The organs that make up the different systems of the body are made of materials called *tissues*. When the various tissues are examined under a microscope they are found to consist of countless small units called *cells*. Cells may be almost any shape. Some are round or oval. Some are rectangular. Others are long and slender. Still others are very angular. All body cells are alike in that they consist of living material called protoplasm usually enclosed by a cell wall.

The protoplasm within the cell wall makes up the living material of the body. Scientists have discovered most of the



*Bone* *Muscle* *Nerve* *Epithelial*

BODY CELLS CONSIST OF PROTOPLASM, NUCLEAR MATERIAL, AND CELL WALL.



MANY SETS OF MUSCLES ARE USED DURING ANY GAME.

chemical substances that are found in protoplasm, but in spite of much research they cannot tell why protoplasm lives.

*Ask your teacher to place different kinds of cells under the microscope. A drop of blood from a pricked finger, a bit of muscle tissue from lean meat, or some of the epidermis (skin) of a leaf will show you characteristic cells.*

### 2. Why are we able to move?

All of the movements of the body are caused by the contraction of the muscles. When we walk, talk, play a musical instrument, write a letter, or drive an automobile, some of the hundreds of body muscles are making this motion possible. The boy or girl who plays a fine game of tennis, or excels in any sport, does so because all of the muscles work smoothly together under the guidance of the nervous system.

Muscles are of two sorts. Those that can be consciously controlled and directed by the central nervous system, such as those in the arms and legs, are called voluntary muscles. Others that are controlled without our becoming aware of an attempt to direct them, such as those in the stomach and the heart, are called involuntary muscles. Each muscle is a group of muscle fibers made up of muscle cells. Approximately one half of the body weight of an individual is due to muscle cells.

Muscles grow larger and stronger with use. Exercise alone will not enable them to increase in size. Protein foods, such as meat, milk, eggs, and fish, are necessary for the development and maintenance of strong, firm muscles.

*Make a collection of pictures of ten foods that will help to build strong muscles. Display them on the class bulletin board.*

Large muscles are of no value unless they are under control. Through daily exercise our muscles are trained to act in the proper way, so that we become skilled as pianists, typists, machinists, or athletes.

### 3. How can we build stronger bones?

There must be some place to attach the many muscles and various organs of our bodies. The bony system, or skeleton, which consists of about two hundred and six individual bones, provides this body framework. Some of these are joined together, such as those that form the skull. Others, as in the fingers and knees, are united by joints so that the muscles can move them about.

Muscles are frequently attached to bones by means of *tendons*. Tendons are cord-like bands of dense, white, fibrous connective tissue that help in pulling the bones about. Have you ever heard of an athlete pulling a tendon?

Ligaments are strong connective tissues that join bone to bone. A sprained ankle or wrist results when a ligament is torn loose from the bone or stretched from its original position.

It is very important to furnish our bodies with sufficient bone-making materials during childhood and youth. If we fail to do so, we cannot hope to have strong and well-developed bones. We can do this if we use generous amounts of milk containing the mineral elements, calcium and phosphorus. The lime in concrete is a compound of calcium. The ability of concrete structures to support great weight is well known. The skeleton also supports considerable weight. Calcium compounds are likewise important parts of all bones, both human and animal. Some foods that are rich in calcium are milk, cheese, oranges, green beans, carrots, spinach, cauliflower, and most leafy vegetables.

*Place a large leg bone of a chicken or turkey in dilute hydrochloric acid for a few days. What changes in the bone do you observe? What part of the bone was dissolved by the acid?*

Children cannot have strong, well-formed bones without sufficient amounts of Vitamin D. Most of us have known a baby who was given daily sun baths, as well as cod liver oil. The sun baths and the Vitamin D from the fish oil cause the calcium to be deposited in the bones, so that deformed bones or rickets are prevented.

*Make a collection of advertisements of preparations which contain Vitamin D. Consult a physician or the school nurse to determine which are reliable. Display the advertisements of recommended products on the class bulletin board.*

We all admire the person who walks along with shoulders back and head erect. Posture is, after all, a matter of habit and of training our muscles to hold our bones in proper position. It is well to think occasionally of our postures, and decide whether we are in good standing or sitting positions. Posture is definitely related to health. The person who stands or sits in a proper position allows his lungs to expand fully, and thus secures a good supply of fresh air. Many digestive disorders, such as constipation, are relieved when the posture is improved.

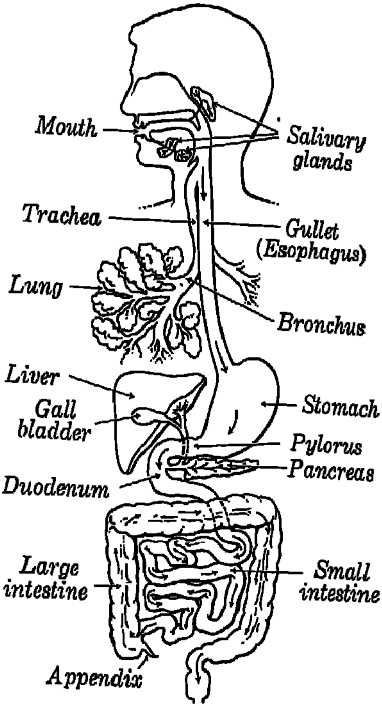
FOR A PERFECT FIT ALL TOES ARE FREE; THE ARCH IS SUPPORTED; THE HEEL IS ALIGNED.

We cannot have good posture unless we wear comfortable, well-fitting shoes, and have feet that are in a healthy condition. Flat feet, due to fallen arches, cause great distress, and interfere with an active, normal life. If your feet trouble you, your physical-education teacher may be able to suggest exercises that will correct the painful condition.

*Place your bare foot as you stand with your weight on it on a piece of white wrapping paper and draw the outline of your foot. Now lay your shoe on this outline to determine whether your shoes are sufficiently long and wide enough for a perfect fit for your feet.*

### 4. How does digestion take place in the human body?

The flour, salt, sugar, and baking powder in the kitchen are not eaten until they are combined with other materials. This often involves a chemical change of some sort. The food that we eat for breakfast, luncheon, and dinner cannot be used for growth and energy in our bodies until it has been chemically changed in our mouths, stomachs, and small intestines. *Digestion* is the name given to the series of chemical changes that occur in food after we have eaten it. It is sometimes defined as the series of processes by which insoluble foods become soluble. *Add a few crystals of rock salt to a test tube partly filled with water. The salt will soon disappear as it becomes dissolved in the water. Salt is a soluble substance. Add several small pieces of marble to a test tube partly filled with water. Does the marble dissolve? Add about 10 drops of concentrated hydrochloric acid to the contents of the tube. Do you see any signs of chemical action? Allow the material to stand until the following day. What has happened to the marble? It became soluble due to the chemical action of the hydrochloric acid.*



OUR FOOD IS OF NO VALUE TO THE HUMAN MACHINE UNTIL IT HAS BEEN CHANGED BY DIGESTION.

Where does digestion begin and where does it end? There are three workshops, or "laboratories," in the digestive system. The first is the mouth, the second is the stomach, and the third is the small intestine. What happens to the food in each "laboratory" is briefly as follows:

In the mouth the teeth cut and grind the food into small pieces. The work of the teeth is called *mastication.* The masticated food is mixed with saliva in the mouth. The saliva acts upon starchy foods, such as bread, rice, and potatoes, changing them into simple sugar. The saliva also moistens all kinds of foods so that they may be swallowed.

A muscular tube called the esophagus, or the gullet, carries the food from the mouth to the stomach. The stomach is a pear-shaped, muscular organ. It provides a digestive substance called the gastric juice. This juice acts upon protein foods, such as meat, cheese, the white of egg, and fish. These foods do not become soluble or dissolved without the help of a digestive juice or ferment, called an enzyme.

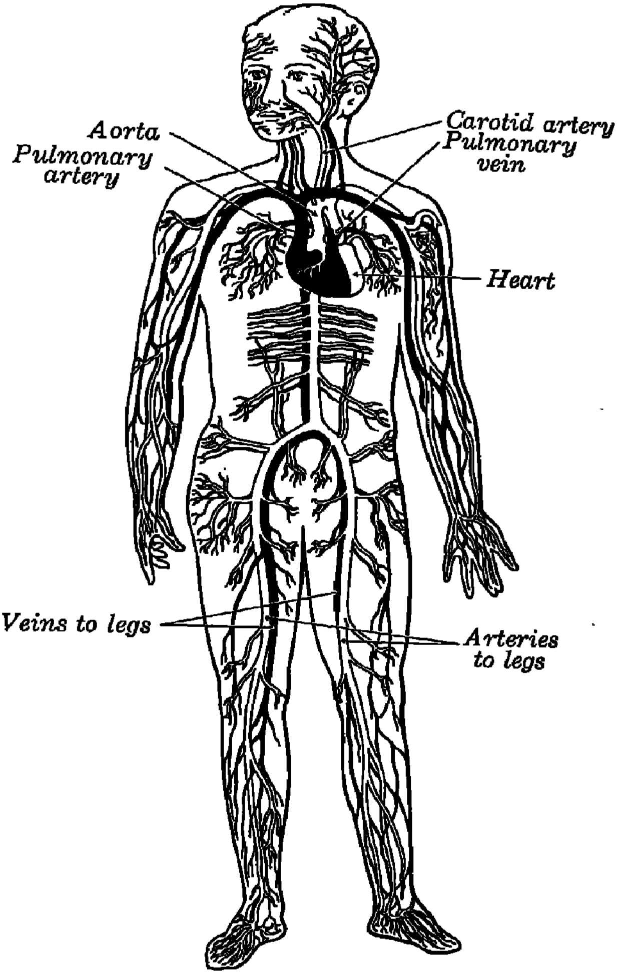
The third "laboratory" is the small intestine. This is the busiest of the three digestive "laboratories." The small intestine is a tube about twenty-two feet long. Two important glands pour their secretions into the upper part of the small intestine. The liver secretes bile, which helps in the digestion of fats. The pancreas provides the pancreatic juice which contains three chemical substances. One of these chemical substances acts upon fatty foods, such as butter, cream, and olive oil. Another digests any starches that were not chemically changed in the mouth. The third acts upon any proteins which were not digested by the gastric juice in the stomach.

All foods are not digested at the same rate. Therefore, several hours must pass before some of the foods that are taken in during a meal are completely digested or made soluble, and are ready to become a part of the blood.

If you could examine the inside surface of the small intestine, you would find that it has a velvety appearance. If a small section were examined under a microscope, many small projections would be observed. Each of these projections, called a villus, contains very small blood vessels called capillaries. The digested food in the intestine passes through the membrane of the villus by a process called *osmosis.*

### 5. How are building materials distributed through our bodies?

We grow in weight and height and have energy to work



THE HEART PUMPS THE BLOOD INTO THE ARTERIES. THE IMPURE BLOOD IS RETURNED TO THE HEART IN BLOOD VESSELS THAT ARE CALLED VEINS.

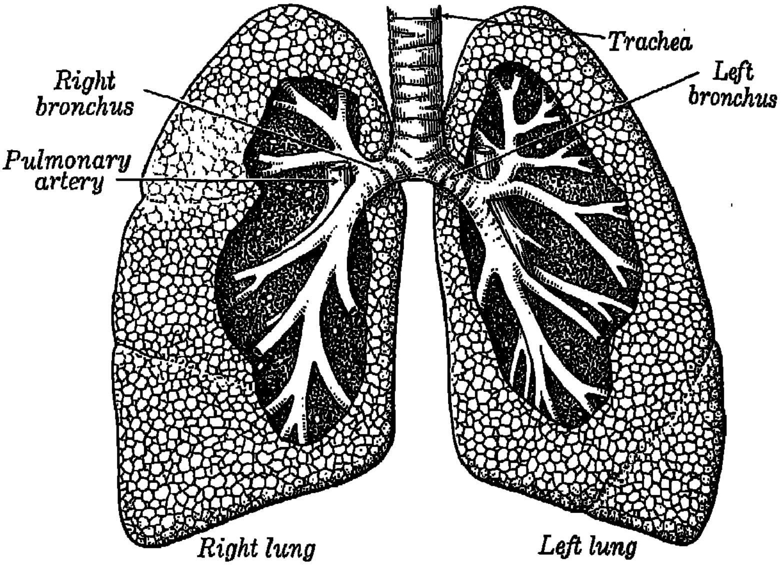
and play because we eat food each day. As we said, this food is not immediately usable for building new body cells, or for providing heat and energy. After the digested food is absorbed into the blood by the process of osmosis, it is carried to the millions of cells in our bodies by the circulation of the blood. The blood is able to travel continuously about the body because we have a double-acting force pump, and more than sixty thousand miles of blood vessels in every adult person.

The double-acting force pump is the *heart.* This muscular organ keeps at work as long as we remain alive, beating not less than seventy times each minute. The heart weighs less than one pound, yet in one day it does enough work to lift a one-hundred-and-fifty-pound weight nearly as high as the Empire State Building in New York City.

The hundred thousand miles of blood vessels are of three kinds. Some are arteries, some are veins, and some very fine capillaries. *Arteries* can be distinguished from veins by their rubbery, elastic walls. Veins are inelastic tubes. Some of the larger veins are fitted with beautifully made valves. Arteries carry blood from the heart to all parts of the body, while veins carry blood from the various parts of the body to the heart. *Capillaries* are fine hair-like tubes which connect veins and arteries. Sometimes you can see fine red lines in the skin of older people. These red lines are small blood tubes.

*Ask your teacher to arrange a microscope to show you the blood circulating in the tail of a small fish, tadpole, or in the web of a frog's foot.*

Chemists cannot write a formula for blood. They know that water is $H_2O$. Unlike water, the chemical composition of the blood is never quite the same. They know that our blood consists of a liquid portion called the plasma. Dissolved or suspended in the plasma are red and white cor-



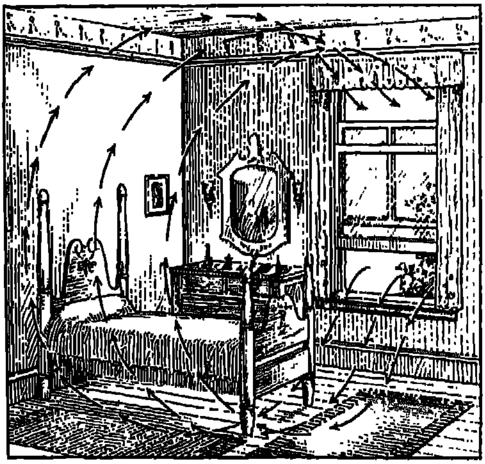
HOW DOES AIR REACH THE LUNGS? WE BREATHE ABOUT 16 TIMES A MINUTE.

puscles, substances that assist in the clotting of the blood, waste materials, oxygen, and dissolved foods and minerals.

### 6. How is oxygen supplied to all of the cells?

Gasoline does not supply power to the automobile until it combines with oxygen. Coal and wood do not burn unless a constant supply of oxygen is present. The digested food does not furnish heat and energy to the body cells unless it combines with oxygen.

In an earlier unit you learned that about 21 per cent of the air is free oxygen. All animals have some way of securing oxygen. Fish obtain it from the water by means of their gills. Most of the insects have breathing tubes called spiracles. Mammals, birds, and many other animals are supplied with lungs through which they obtain the life-giving oxygen.



GOOD HEALTH REQUIRES FRESH AIR.

Our lungs contain many millions of tiny air sacs. When we take a deep breath they are filled with air. As the blood circulates through our lungs, oxygen from the air enters the blood stream and is carried to all of our body cells. The blood carries waste materials from the cells. As these wastes are carried to the lungs carbon dioxide, nitrogen, and water are breathed out by the lungs.

The importance of a continuous supply of fresh air day and night can be readily understood if we remember that usually a person cannot live longer than three minutes without oxygen. Many colds and other illnesses are due to poor ventilation in an overheated and crowded room. If we remember that cold, fresh air enters through the lower part of the opened window, and that warm, stale air escapes through higher openings, we can arrange the ventilation in our rooms in a healthful manner.

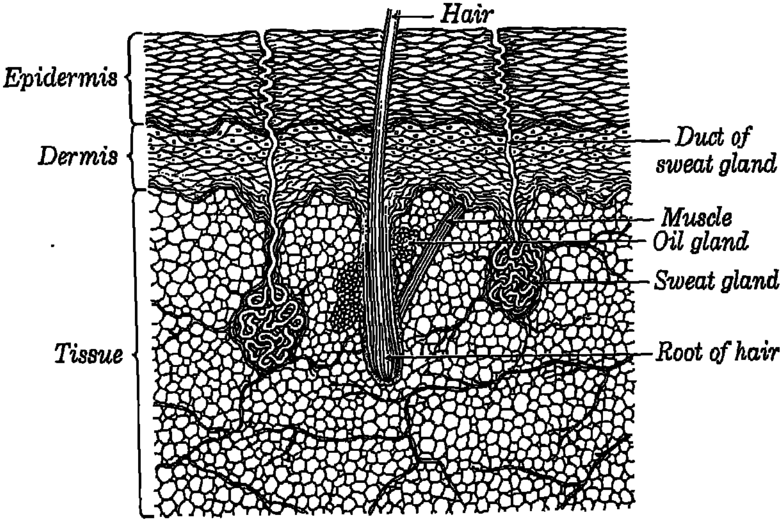
## 7. What defenses has the body against injury and disease?

Germs, or microbes, are all around us. They seldom do harm because we are provided with a protective covering called the skin. The skin of an adult person covers an area of about twenty square feet, and weighs about six pounds. If we carefully examine a bit of skin under the microscope we find that it is made of many cells. The outer layer of skin is called the *epidermis,* and the inner layer of skin the *dermis.*

The germs that come in contact with the skin are usually destroyed or removed by the daily bath of warm soapy water. When the skin is broken by cuts or scratches, bacteria may enter and cause trouble if no precautions are taken. We have formed a good habit when we always apply tincture of iodine to every cut or scratch, no matter how slight it may be.

If the skin is injured by burns or scalds, wet baking soda or vaseline may be applied. A tannic-acid solution made by soaking tea leaves in warm water is also used for burns. Large and deep burns require the immediate attention of a skillful physician.

The eyes protect us from some accidents and injuries. We can see that food has become moldy or spoiled, and do not eat it. If water looks murky, we do not drink it. However,



THE HAIR AND NAILS ARE OUTGROWTHS OF THE SKIN. NOTE THE SWEAT GLANDS THAT ARE DEEP IN THE DERMIS.

pollution is not always visible. If a road or bridge appears unsafe, we turn around and choose another safer route.

The eyes are much like a camera. Each has a *lens* that focuses the object on the film in the camera, and on the *retina* in the eye. When a camera wears out we can replace it, but our eyes through which we gain the most of our knowledge cannot be replaced.

We can do much to safeguard our eyes if we read or sew only when there is sufficient light. If our eyes need the assistance of glasses, we should be glad to wear them. Sometimes eyes become stronger as children grow older, and in time glasses become unnecessary.

The sense of smell, located in the nose, protects us in many instances. If food has become soured or spoiled, the olfactory sense, or the sense of smell, will warn us not to use it. A leaking gas line, which might result in an explosion or in asphyxiation, is frequently found by this detective, the nose, before any serious harm has been done.

Another of the special senses is the sense of taste. When materials are placed on our tongues they give the sensation of being sweet, salt, sour, or bitter. This sense sometimes prevents us from swallowing harmful substances.

The white corpuscles in the blood have been mentioned. They are sometimes called the policemen of the body, because they destroy bacteria and other kinds of disease germs. If bacteria enter through a cut or a scratch and start to cause trouble, the white corpuscles gather in that area in large numbers and destroy the germs. The pus, which sometimes forms in wounds, is proof that the body police have responded to the emergency.

Another of the defenses of the body is known as *immunity*. By immunity we mean that substances are built up in the tissues and in the blood which counteract the poisons produced in the blood stream by disease-producing organisms. Some people seem to have natural resistance to certain diseases, which is called *natural immunity*. Some races seem to be more likely to suffer from tuberculosis than others who do not have this natural immunity.

You know that persons having had one of the common contagious diseases, such as measles, chicken pox, or whooping cough, do not have the disease again. The resistance that they have developed to the disease after having had it is called *acquired immunity*. We do not know just what produces immunity. It is thought that chemical substances are formed in the blood because of the presence of poisons produced by the disease-producing bacteria.

It is possible to acquire immunity to some diseases by introducing a substance into the blood of the person to be made immune. Sometimes the substance consists of weakened germs of the disease. In other cases a vaccine serum, or antitoxin, is used which was prepared from the blood of a healthy animal that had the germs of the disease introduced into its body.

Many people now avoid having smallpox, diphtheria, typhoid fever, and other diseases because they acquire immunity through the use of vaccines and antitoxins.

*Prepare for the class a report on the methods that are used in the preparation of smallpox vaccine and diphtheria toxin antitoxin.*

### 8. How can wastes be removed from the human machine?

Machines form wastes as they consume fuel. Various gases are formed in the automobile motor as the gasoline is burned. Ashes always result from the burning of wood and coal. Four types of waste products are produced in the human machine. It is very important that these wastes be removed soon after they are formed, if the body is to remain in good health and if it is to do its work efficiently and well.

There are many sweat glands in the skin. They secrete *perspiration.* Perspiration is largely salt water in which protein wastes from broken-down muscle cells are dissolved. During vigorous exercise, or in very warm weather, several quarts of perspiration may be given off in one day. If the weather is cool, or we do not exercise, such small amounts of perspiration are produced that we are not conscious of perspiring.

It is important that this perspiration should not be allowed to remain on the skin for any length of time. A warm bath each day and a change of underclothing and stockings will help to keep the skin in a clean and wholesome condition.

The air that leaves our lungs contains a waste product called *carbon dioxide.* Some rather strenuous exercise each day, such as a walk, will help to remove the carbon dioxide. Because at such times we breathe more rapidly and deeply, the circulation of the blood is increased so that the carbon dioxide is removed from the many cells in our bodies. As the blood circulates around the body, it takes on the carbon dioxide. When the blood reaches our lungs, the carbon dioxide is exhaled and fresh air with the life-giving oxygen takes its place.

*You can prove that carbon dioxide is a part of the air that leaves your lungs by the following experiment: Pour some limewater into a test tube or glass. Blow through a glass tube or straw, such as is used at a soda fountain, into the limewater. The clear limewater will become milky. This is a good test for the presence of carbon dioxide.*

The kidneys are very important organs of excretion. They are bean-shaped organs, about four inches long, which give off a liquid waste called *urine.* There is a substance called urea in this waste, which like a substance in the perspiration, is formed from broken-down muscle cells. One reason why we should drink at least six glasses of water every day is to make sure that the kidneys do their work efficiently.

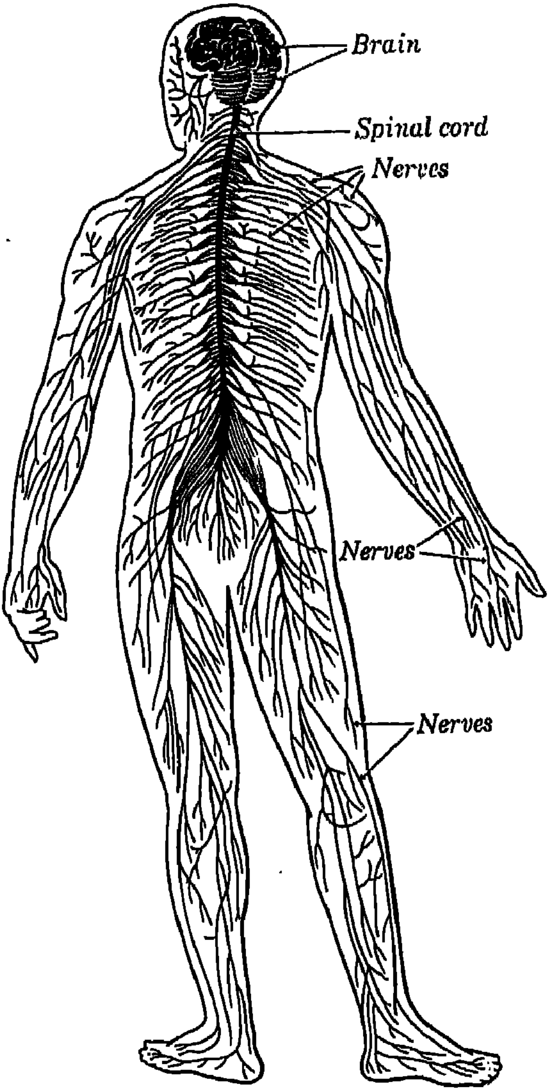
The large intestine is sometimes called the colon. It forms the lower part of the digestive tract and is continuous with the small intestine. This tube is about five feet long in an adult and excretes the solid wastes of food and bacteria. At least one bowel movement daily is essential to prevent the common ailment called constipation. Constipation is a frequent cause of headache, upset stomach, and a blotchy or pimply skin.

### 9. What guides and controls the human machine?

No machine is of value unless it is under control. There is no more pitiable sight than a human machine that is undirected, because for some reason the nervous system is not functioning as it should.

The nervous system consists of the brain, the spinal cord, and the nerves. We hear, see, feel, and have the senses of smell and taste, because certain nerves carry the messages called sensations to the brain. We move our legs, arms, and fingers only when the brain sends out the command to certain nerves called motor nerves. We are intelligent beings, able to control our environment, and able to live in all of the climatic zones, because we have a highly developed brain with well-established powers of reasoning.

Everyone admires the alert, clear-thinking, self-controlled person. We frequently hear the expression that it is brain and not brawn that counts. Some of the most valuable members of a football team are the boys who do not have the greatest size and weight. The individuals whose muscles re-



OUR NERVES EXTEND THROUGHOUT OUR BODIES. FOR THIS REASON WE HAVE THE SENSE OF FEELING IN ALL PARTS OF OUR BODIES.

spond quickly and accurately to the brain's directions are often responsible for the victories in match games.

The health of the nervous system depends first of all upon sufficient rest and sleep. Very young babies sleep most of the time. The hours of sleep which are necessary decrease as we grow older. The following table was worked out by experts in the United States Children's Bureau:

SLEEP REQUIRED BY THE AVERAGE CHILD

| AGE | HOURS OF SLEEP NEEDED |
|---|---|
| At birth | 20 to 22 hours |
| At 6 months | 16 to 18 hours |
| At 1 year | 14 to 16 hours |
| At 2 to 5 years | 13 to 15 hours |
| At 6 to 7 years | 12 hours |
| At 8 to 10 years | 11 hours |
| At 11 to 12 years | 10 to 11 hours |
| At 13 to 15 years | 9 to 10 hours |

The avoidance of drugs and poisons is another requirement for a healthy nervous system. The poison that is most likely to be used by growing boys and girls is nicotine. Nicotine is a part of tobacco, and is, therefore, found in all cigarettes. Tobacco is much more injurious to boys and girls than it is to older people. Some schools have found that the grades of the students who smoke are below those of the nonsmokers.

As boys and girls become older they may be tempted to use drinks that contain alcohol. Alcohol is a poison, and one of its effects upon the body is seen in the nervous system. Good judgment and self-control rapidly diminish under its influence. No one can give the exact amount of alcohol that is necessary to produce drunkenness, because most people vary in the amount they can drink and still remain sober.

Railroads have a strict rule which prohibits the use of alcohol by their employees, because they are responsible for the lives of the passengers and hundreds of thousands of dollars' worth of equipment. The officials of the large airline companies enforce the same rule. Often a man who drinks will not employ a chauffeur who is a user of alcohol. Many automobile accidents upon the streets of our cities and on our highways are caused by drunken drivers. Drunken pedestrians are likewise the cause of frequent accidents involving an automobile.

It is quite true that we are a bundle of habits. Habits become fixed by doing the same thing many times in the same way. Finally, in similar situations we tend to perform an act in the same way. Good manners, neatness, various kinds of accuracy, and a happy, cheerful disposition are the results of the formation of good habits formed while we are boys and girls.

### 10. How can we best care for our own bodily machinery?

We know that the human body is a very complicated organism. It is composed of several systems. Each system is composed of various organs. Usually the different organs develop and work together harmoniously. We can do much to promote good health by developing habits of healthful living.

We can choose simple, wholesome foods that will build and help to maintain strong bodies. At least a pint of milk should be used by every junior-high-school boy and girl each day. In addition there should be a generous use of fresh vegetables, whole wheat bread, and fresh fruits.

Fresh air is necessary for good health. In cold climates

A NOURISHING LUNCH IS ONE OF THE REQUIREMENTS FOR THE HEALTH AND GROWTH OF ALL CHILDREN.

some children attend open-air schools throughout the year. Exercise taken in the fresh air and sunshine is an excellent tonic.

Warm, yet light, clothing should be the rule in cold weather. In hot weather clothing that allows the escape of body heat should be used. We should choose our clothing according to the thermometer, and not the calendar. Strong shoes that keep the feet dry in wet weather are an essential part of everyone's wardrobe.

Cleanliness of skin, hair, teeth, and clothing are necessary for health as well as for our own self-respect. Many capable boys and girls have not been chosen to fill positions because of their personal appearances.

Some boys and girls who would not think of coming to school without washing their faces appear without having brushed their teeth. From a health standpoint, a dirty face is less harmful than dirty teeth. It may not always be true that a clean tooth never decays, but clean teeth decay much less frequently than those that do not receive proper care.

How shall we care for our teeth? The teeth must be brushed at least twice each day—when we arise in the morning, and just before going to bed at night. We should see a dentist every six months, so that small cavities may be filled before the entire tooth is destroyed. Pride in our personal appearance, as well as a desire to have good health, will cause us to care properly for our teeth.

A boy or girl who does not have sufficient rest and sleep cannot have good health. Remember that the body and the nervous system are subjected to great strains in this modern world. Long hours of restful sleep help to rebuild or restore all kinds of body cells.

### THINGS TO DO

1. Keep a list of the foods that you ate at breakfast, luncheon, and dinner during any one day. Use reference books to help you decide what kinds of food substances they contain. Then classify them under the headings of proteins, fats, carbohydrates, and minerals.
2. Interview a dentist or nurse and then write a report for the class on the subject "How to Have Good Teeth."
3. Weigh yourself weekly for at least 10 weeks. Then make a graph to show your increase or decrease in weight.
4. Make a list of at least 10 foods that help to build strong teeth and bones. Post your list on the class bulletin board.
5. Collect news items concerning accidental injuries. Use these items for material for a chart having the following headings:

Accidents, Their Nature and Prevention

| NATURE | CAUSES | RESULTS | POSSIBLE PREVENTION |
|---|---|---|---|
| | | | |

6. Make a poster showing how injury to the eyes can be prevented.
7. Prepare a first-aid kit which will be suitable to take with you on overnight hikes and on trips in the family car. Consult the school nurse or family physician as to the most useful materials to include.
8. Prepare a report for the class on William Harvey who discovered the circulation of the blood.
9. Consult some book such as *Living Safely* by Bowman and Boston and prepare a report for the class on the correct first aid to be applied in the case of cuts, punctures, and burns.

### SOME THINGS TO REMEMBER

1. The human machine derives energy from the food that is eaten.
2. A cell is the smallest unit of living material.
3. Muscles make bodily movements possible.
4. The skeleton, or bony system, provides the body's framework.
5. Good posture is related to good health.
6. Strong bones depend upon sunshine and a plentiful supply of foods containing calcium and Vitamin D.
7. Foods must be digested before they can be used in the body.
8. The heart pumps the blood to all parts of the body.
9. The blood distributes the digested food.
10. We cannot live without a constant supply of oxygen.
11. The skin protects the body against the entrance of some kinds of germs or microbes.

12. The eyes and nose protect the body against many dangers.
13. The white corpuscles in the blood destroy bacteria when they enter the body.
14. Perspiration is a waste product excreted by the skin.
15. The air that leaves our lungs contains waste products, including carbon dioxide and water.
16. The kidneys excrete a liquid waste called urine.
17. The colon or large intestine should be emptied each day.
18. The nervous system is made up of the brain, spinal cord, and nerves. This system controls the human machine.
19. Sufficient sleep is necessary for the proper development of the nervous system.
20. Poisons, such as tobacco and alcohol, may be very injurious to the nervous system.

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